UNIVERSITY OF BRISTOL.

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OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,

1934.

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

It was stated in the last Annual Report that after the two very difficult years of 1932 and 1933 in respect of finance, illness and other disturbing factors, the outlook at the end of the latter year was more hopeful than at any other time earlier in its course. To a large extent that promise has been realised during 1934. By rigid economies the large adverse balance of the previous year has been avoided on this occasion and expenditure has been kept just within the limit of income. Fortunately, too, illness among members of the staff has been considerably less and the progress of work has not been hampered so greatly on that account. In various other ways, also, conditions have been more settled and conducive to steady work.

On the other hand there have been several causes which have operated against the Department functioning to full efficiency. An extremely serious blow was sustained by the death of Dr. Hiatt C. Baker, the Chairman of the Finance and Business Sub-Committee and Treasurer of the Long Ashton and Berkeley Square centres. Dr. Baker had held these offices but a short time, having been appointed to them on the death of his predecessor, Dr. H. B. Napier, at the end of 1932. Throughout the whole period of his brief tenure of office he was faced with adminstrative and financial problems of an intricate and difficult character; and it has been due to his wise and experienced guidance that they have been surmounted with a very considerable degree of success. His sudden death in September, 1934, unhappily occurred a few hours too soon for him to hear that his financial policy had resulted in the Department having surmounted its financial crisis and paid its way during his one complete year of office. The severity of the Department's loss, heavy as it is on the administrative and financial side, is amplified in this particular case, where horticulture occupies a pre-eminent position, in that Dr. Baker himself among his many qualifications possessed a very wide knowledge of horticulture and an enthusiastic interest in the subject. In succession to him Capt. Douglas M. Wills has recently accepted the offices in question. The Department must be accounted fortunate to have secured the services of one who not only has an extensive personal experience of practical agriculture but, at the same time, as Chairman of the Somerset Agricultural Instruction Sub-Committee and of the Governing Body of that County's Farm Institute at Cannington, is in the closest possible touch with agricultural and horticultural educational and experimental work in the county in which the Long Ashton Research Station is located.

It is an unhappy coincidence that the Treasurer of the Campden Station, Mr. A. Woodall, has been laid aside on account of illness throughout the year. Thus, during the period when active negotiations relating to the future of that Research Station have had to be proceeded with, it has been deprived of his services and has missed the valuable help which would have been forthcoming otherwise from one so intimately in touch with the canning industry and so keen a supporter of the Station. In addition, that Station has been handicapped during a part of the year by the ill-health of its two senior members of staff, Mr. Hirst, the Resident Director, and Mr. W. B. Adam.

Without going into details of the activities of that Station throughout the year—these now being recorded in its own separate Annual Report—some reference must be made here to the arrangements which are being negotiated for the future of that Station on account of their bearing upon the Department as a whole. It may be recalled that in October, 1930, the Station was placed on a revised financial basis, designed to cover a 5-year period, during which the more permanent nature of the Station could be considered and settled. That period expires in September, 1935. For the period the Ministry of Agriculture promised an annual grant of £3,000 on condition that the canning and allied industries provided the remainder of the money required for the maintenance of the work. The sum forthcoming from the industry for that purpose has increased annually till, in 1933-34, it approximated to £1,500. The Agricultural Committee of the University appointed a special Sub-Committee to manage the affairs of the Station, the membership of that body including representatives of the canning industry subscribers. At the time, it was contemplated that ultimately the Station might become the research and advisory centre of a Canning Research Association, separated from the University of Bristol, working in conjunction with the Department of Scientific and Industrial Research, as in the case of various existing trade research associations, and receiving a Government grant from that Department instead of the Ministry of Agriculture. The point of such an arrangement was that the canning industry was rapidly becoming industrial rather than agricultural and, as such, should be allied with the Department rather than the Ministry. The prolonged negotiations which have been in progress have now reached a stage when it can be reported that general agreement of all parties concerned has been arrived at along the following lines. The Station will continue in existence as a research centre more or less as at present in respect of finance and control with the exception that the grant from the Treasury will be made through the Department of Scientific and Industrial Research instead of the Ministry of Agriculture. The latter, as at present, will be represented on the Management Committee, and the Food Investigation Department, the branch of the Department of Scientific and Industrial Research to which the work of the Station most closely appertains, will also be given representation on that body. The Station will remain attached to the University in some form, probably as at present as a part of this Department ; and the University will retain general responsibility for its administration. It is understood that, in the event of the cost of maintenance of the work of the Station increasing, the additional expenditure involved must be met by increased contributions from the canning industry. Along those general lines it should be possible to continue the work of the Station with the minimum amount of interference with existing arrangements.

Apart from the unsettlement attendant upon these adverse causes, the efficiency of the work of the Department has been affected mainly by two factors—the general financial position and the constant increase in its activities. The standing financial commitments grow each year owing to the automatic increase in salaries of non-graded members of the staff and the superannuation charges associated therewith,—which have to be provided out of a maintenance grant practically stationary in amount—the increase in general maintenance expenditure on items which have been curtailed or deferred since the grant cuts of 1931 until further delay has been impossible, and the steady growth of the calls upon the staff of the Department consequent on the natural expansion of its work. The charges under each of these heads have to be met and no corresponding increase in income is available. As a result additional pressure of work has fallen upon the staff generally, since the required additional man-power cannot be provided. Where all are more or less concerned it may be invidious to specify individual cases, but mention should be made of two particular directions in which the pressure has been especially acute. On the pomological side the calls for advisory assistance, coupled with the expanding experimental work in progress in the plantations at Long Ashton and at outside centres, threaten drastic curtailment of activities unless extra staff can be provided by some means. A similar situation exists in respect of the section dealing with cider and other fruit products. The staff in both these sections, especially those at the head, are so fully occupied that breakdowns in health may follow unless the load is lightened.

Thus, satisfactory though the position may be, as the following report shows, in the direction of continued expansion of the utility of the Department, it cannot be too strongly emphasised that this is now being achieved at the risk of the health of the staff, and that a choice is imperative and imminent between limitation of activities and additional man-power. Unless extra financial aid is forthcoming the former alternative is inevitable. It is difficult to recognise sufficiently warmly the personal efforts of the staff concerned in maintaining the work under conditions so strenuous and calling for so much self-sacrifice. It is hoped that those applying to the Department for advisory assistance who may read this will appreciate that prompt service under the conditions is at times impossible and any lack of it in such cases beyond the power of individual members of the staff to rectify.

It should be mentioned also that the non-graded and labour staffs of the Department share in various ways the strain to which it has been subjected by the expansion of its work under financial restrictions. They have merited the assurance of those in authority that, although it has not been possible to show adequate appreciation in tangible form, their part in the efficient conduct of the activities of the Department has not been overlooked.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

At Berkeley Square, Mr. J. D. Nutt, B.A. (Economics), after several years service as Student Assistant to Mr. Dawe, the Advisory Officer in Agricultural Economics, has received promotion to a more responsible post in the same subject at Armstrong College, Newcastle. He is succeeded by Mr. S. R. Wragg, B.A. Mr. L. J. Hewett, hitherto engaged upon the grassland investigations of the Centre, has also been appointed to fill an existing vacancy of a similar order on the staff of this Section of the Department resulting from the death of Mr. E. C. Velten.

General.

The Centre has been given a special grant of £400 for one year in the first instance from the Milk Marketing Board, through the Ministry of Agriculture and Fisheries, for costing work in connection with milk production.

It has also received a special grant from the Ministry to meet travelling expenses incurred in connection with an economic survey of willow growing carried out in Gloucestershire and Worcestershire at the request of the Ministry.

During the year the Agricultural Officer, Mr. A. W. Ling, was enabled to attend the Third International Grassland Conference at Zurich as a result of a grant from the Ministry.

On behalf of the Bath and West Society, the Agricultural Officer in conjunction with Mr. W. T. Price, the Agricultural Organiser for Wiltshire, is making an investigation and survey on pig husbandry in the south-western counties.

Throughout the year the Agricultural Officer has organised a series of broadcast talks for farmers which have been included in the West Regional Station programmes. About 20 of these talks have already been given. Through them close touch has been established with many farmers throughout the Bristol Province.

LONG ASHTON RESEARCH STATION.

Staff.

At Long Ashton, few staff changes have occurred during the year and none of the senior posts have been affected. Mr. B. O. Mulligan, N.D.H., who has assisted Mr. L. Ogilvie during the past four years in his investigations on the diseases of market garden crops and their control, vacated his post last July on receiving an appointment in one of the commercial nurseries. His successor, Mr. P. W. Brian, M.A., is a Cambridge graduate with mycological research experience at that University subsequent to taking his degree.

Mr. I. Dembrey, B.Sc., appointed in 1933 for chemical work arising in connection with the administration of the National Mark Scheme for Jam, resigned in 1934 on receiving the offer of a post in the Public Health Department of the City of Bristol. Mr. F. C. Lewis, M.Sc., previously an assistant research worker on the general chemical staff at the Station, has taken over his duties and his former position in turn has been given to Mr. J. E. Kench, B.Sc. Each of these three is a graduate of Bristol University.

To give Miss Adams, who has charge of the work on Domestic Preservation of Fruit and Vegetables, an opportunity of carrying out a special programme of research during the fruit season, arrangements were made to relieve her of continuous attendance at the courses of instruction on this subject held at the Royal Agricultural College, Cirencester. These courses, arranged by her, have been carried out at the College for the past few years since her transfer from Chipping Campden Research Station. Arrangements were made with the East Anglian Institute of Agriculture to secure the services of Miss Jameson as Instructress at these courses for the season, and the thanks of the Station are due to the Governing Body and Director of the Institute for releasing her for the purpose.

During the year discussions between representatives of the Imperial Chemical Industries, Limited, and the Station resulted in the former making a grant for an extension of certain investigations on fungicides and insecticides for a prospective period of three years. This special work has been placed in the hands of Mr. A. C. Evans, B.Sc. (Bristol), whose previous research experience for four years at the London School of Hygiene and Tropical Medicine has already proved very useful in connection with the present problems in hand. In this work he is proceeding in close touch with the other members of the staff engaged in research on plant disease and pest control.

A very useful supplement to the work of the permanent members of the staff of the Department has resulted from the individual investigations and personal assistance of various post-graduate workers and honours degree candidates attached to the University of Bristol. The former group include Miss M. Carleton, B.Sc., and Miss T. H. Donisthorpe, B.Sc., both of whom have been engaged upon entomological research; Mr. H. M. Hutchinson, B.Sc., who has assisted in mycological investigations; Mr. N. Colquhoun, B.Sc., whose services in the Fruit Products section have made possible an extended programme of research in that subject; and Mr. Sham Singh, a graduate of the University of Punjab, and a member of the staff of the Punjab Agricultural College, Lyallpur, who has been engaged upon certain pomological researches at Long Ashton. The following three undergraduate members of the University, Mr. B. N. Swanton, Mr. C. H. Hardy, and Mr. K. F. G. McMurray, have rendered much appreciated assistance in various directions concerned with the plant pathological research programme of the Station.

Buildings and Land.

In consequence of the general financial position of the Station it has not been possible to face the provision of additional permanent buildings, the need for which was indicated in the last Annual Report. Temporary arrangements, however, have been made to provide accommodation for certain sides of the experimental work. The wooden building adjacent to the cider house, originally erected during the war for work undertaken for the Ministry of Food, has been brought into use for semi-commercial scale experiments associated with investigations on fruit products.

The expansion of the laboratory side of the work on this subject and of the analytical and other work undertaken for the Ministry of Agriculture and Fisheries in connection with the National Mark Jam Scheme has involved the transfer of most of the analytical work connected with cider to the original small laboratory adjacent to the cider house. This has been used for some years for other purposes and has now been refitted to make it suitable for the analytical work mentioned.

The main laboratory building is now overcrowded and difficulty is being experienced in finding room to accommodate post-graduate workers. A small addition to this building in the near future for certain sections of the chemical work is under contemplation.

The exchange of land with the Ashton Court Estate referred to in last Annual Report has made it possible to proceed with plans for an extensive series of trials of various systems of culture of cider fruit. These trials have been devised so as to furnish information on stock and scion relationships of general pomological interest. The land in question, hitherto under grass, has been broken up and cropped with vegetables during the year in preparation for the planting of the trees.

A further plot of ground, about 8 acres in extent situated near the northern boundry of the farm and as remote as possible from the main fruit plantations, has been prepared for investigations on the control of diseases and pests of fruit trees. The required trees have now been planted. The plot as a whole will serve as a centre for spraying and other trials which hitherto have had to be carried out on experimental fruit plots at the Station established primarily for other investigations. The difficulties arising from this dual purpose use of such plots will thus be largely avoided in future. The establishment of this new pathological plot has been made possible by a special grant made by the Agricultural Research Council.

A pear rootstock variety trial has been estblished on a plot of ground which was previously occupied by plum and other trees, the experiments on which have now been completed and the trees grubbed. This new pear plot consists of 500 trees of six varieties. which are being tested on two quince and two pear rootstocks. The pear trees are interplanted with Raby Castle red currants, the latter having been obtained from a number of sources throughout the country in order to determine, if possible, the cause of the present unsatisfactory cropping of this particular variety.

Additional planting of cider trees in the new hillside orchard has been carried out during the past planting season, and nearly the whole of the land available in this orchard is now occupied with trees. The orchard will probably be completed during the next planting season.

General.

The Annual Open Day of the Station was held on Thursday, May 3rd. The programme for the day followed the usual lines, the plantations being thrown open for inspection and the competition ciders being set out in the cider house for sampling purposes.

The special features of the day included demonstrations of (*a*) the headworking of 40-year old standard apple trees, (*b*) common systems of staking young orchard trees, and (*c*) the spraying of cider apple trees with a mixed wash for the control of the major pests and diseases by a single wash application. A comprehensive exhibit contributed by the Ministry of Agriculture and Fisheries, dealing with its National Mark Schemes for the marketing of agricultural and horticultural produce, was staged in the cider house and created considerable interest.

Once more the weather was favourable for the day and a very large and representative attendance was obtained. Mr. H. V. Taylor, O.B.E., Commissioner of Horticulture to the Ministry of Agriculture and Fisheries, distributed the prizes in the Cider Competitions and gave a short address, in the course of which reference was made to current topics of interest to fruit growers and cider makers.

As usual, several organised parties visited the Station during the year. Among such parties special reference may be made to one comprised of 35 French horticulturists and cider makers from Normandy and Britanny, and another composed of German fruit growers and horticulturists, arranged by Professor T. Roemer, of the Plant Production and Plant Breeding Institute of the University of Halle. Other parties included the following :—

Fruit Growers from Aber, Carnarvon.
Colston Girls' School, Bristol.
Horticultural Section of Messrs. Mardon's Evening Club, Bristol.
Clifton High School Students.
Association of Women Science Teachers.
Gloucester Teachers.
Bristol Pharmaceutical Society.
Devonshire Teachers.
Bristol University Chemical Society.
Somerset Branch of the Sanitary Inspectors' Association.
Biochemical Society of Birmingham University.
Messrs. Fry's Pensioners' Association.
Clifton College Scientific Society.

Filton Co-operative Mens' Guild.
Monmouthshire Agricultural Institute Students.
Herefordshire Gardeners' Association.
Garden Section of Army Vocational Training Centre.
Kingswood and District Employees Hospital Guild.
Great Western Railway Institute and Welfare Association.
Bristol City Football Club.
Bristol Conservative Women's Association.
Bristol Federation of the League of Industry.

In addition to these parties the Station was visited by many other persons, some to view the general work of the Station, and others to consult individual members of the staff on particular problems. The list of visitors included many scientists and horticulturists from overseas.

The Show activities of the Station during the course of the year were curtailed as far as possible in view of the necessity of restricting expenditure in this direction and of reducing the calls on the time of members of the staff, the considerable expansion of the work of the Station having made this latter course necessary. Special reference may be made to the exhibit organised by the Station, in conjunction with the Horticultural Superintendents of the counties in the cider fruit growing areas, which was staged at the Autumn Show of varieties of apples and pears organised by the Royal Horticultural Society and held at the Crystal Palace in September. The thanks of the Station are due to all who assisted in bringing together what was probably the most comprehensive collection of cider apples and perry pears ever staged in this country. The other shows to which exhibits were sent during the year are named in the following list :—

Devon County Show, Newton Abbot.
Asparagus Growers' Show, Evesham, Worcs.
Bath and West Show, Oxford.
Royal Counties Show, Salisbury.
Three Counties Show, Hereford.
Cheltenham Spa Floral Fete, Cheltenham.
Royal Agricultural Society's Show, Ipswich.
Gillingham and Shaftesbury Show, Shaftesbury, Dorset.
British Association Meeting, Aberdeen.
Imperial Fruit Show, Leicester.
Brewers' Exhibition, London.

The extra mural work of the Station is constantly growing and many important investigations and experiments are in progress on fruit farms and elsewhere throughout the country. For the facilities made possible by such co-operation the Station is greatly indebted to the various individual growers concerned. Similarly, valuable links with other Institutions through conjoint work and consultation have been established and maintained.

A COMPARISON OF THE PICKING COSTS OF SIX COMMERCIAL VARIETIES OF BLACKCURRANTS.

By T. SWARBRICK and C. R. THOMPSON.

Under modern conditions of fruit growing, success appears to depend very largely upon the wise choice of suitable varieties for the particular market that it is sought to satisfy. The factors which, taken together, make a variety a commercial success are numerous, and in some cases it may be small differences in season of ripening, in quality, yield, colour or picking costs which finally lead to the choice of one variety in preference to another.

The present paper summarises results that have been obtained in an enquiry into the relative costs of picking six commercial varieties of blackcurrants. It was initiated because it was realised that the cost of picking blackcurrants represented one of the major single items of expenditure in production. The enquiry covers the five year period 1930 to 1934 inclusive, and is part of a comprehensive investigation into the cropping, pruning and disease control in six blackcurrant varieties growing in a variety trial at Long Ashton. It is well known that varieties yield differently, but it is not so well known that the cost of picking one ton of fruit varies widely amongst the several varieties.

In estimating the possible production cost of any particular fruit crop, the producer must not only estimate the probable yield, but also the relative cost of picking the crop. With soft fruit, such as raspberries, strawberries and black currants, the cost of picking may in some cases be as much as 25 per cent. of the gross selling price, and it is therefore a matter of considerable economic importance. Assuming that picking costs remain constant, then the lower the gross selling price of the fruit the more important does picking cost become in the economy of fruit production. Even at the very modest price of ½d. per pound, the cost is at least £4 10s. per ton for picking.

Experimental Procedure.

Material. The data presented in this report were obtained from bushes on variety trial plots, some preliminary results of which were published in the Annual Report for 1931.

Two separate collections or groups of bushes have been used. The first group is referred to as the "Wisley" material, since it was originally supplied by the Royal Horticultural Society, and comprises a large scale variety trial. This group of material is made up of 104 bushes of each of the varieties Baldwin, Boskoop and Taylor, and 103 bushes of the variety Davison's Eight. The second group of bushes is known as the "Long Ashton" material and constitute a variety trial and pruning experiment. This comprises 184 bushes of each of the varieties Baldwin, Boskoop and Edina and 192 bushes of the variety French or Seabrook's Black.

The materials were all planted as two-year-old bushes in the winter of 1927-1928 at a uniform distance of 6 by 5 feet, and were cut down immediately after planting. The treatments of the two groups of bushes have not been identical, but the differences are immaterial in the present discussion.

Method of Collecting Records. Although the bushes carried their first crop in 1929, data relating to picking costs were not obtained until the following year, viz. 1930.

The method of taking the time records was simple yet effective. On each occasion that the women pickers, usually about 35-40, went on to the plot, a count of their number was made and this was recorded along with the time at which picking began. A second entry was made when picking was completed and from these records the total time taken to pick a given amount of fruit was calculated. In all cases crop yields of individual bushes or groups of bushes were being obtained, so that it was an easy matter to determine such points as picking cost per ton, etc.

It must be pointed out in this connection that at Long Ashton all fruit is picked by women working upon an hourly basis. Piece-work rates of so much per pound of fruit picked cannot be adopted, in view of the particular nature of the work involved. In the present case, for example, the fruit from each bush had to be kept separate for weighing. The women, therefore, work under the immediate supervision of one or more recorders whose duty it is to see that the work is properly carried out, and they are paid at the uniform rate of sixpence per hour for all work.

On the particular plots, the bushes of each variety are distributed in randomized groups and in consequence a considerable amount of time is spent in walking from one group of bushes to another, which renders the cost of picking rather high. Picking costs, however, are comparable as between the six varieties.

Results.

The results of this study are given in considerable detail in Tables I and II. From these tables growers and experimenters can make such other comparisons as they may desire. The data given include the total crop each year from a stated number of bushes; the average crop each year from a stated number of bushes; the average crop per bush; the average time taken to pick one bush and also one ton of fruit; and the average cost of picking one bush and one ton of fruit.

A. Wisley Material.

The data for this material are given in Table I. The material comprises the four varieties Baldwin, Boskoop, Taylor and Davison's Eight, with 104 bushes of each sort, except the last mentioned, of which there are only 103 bushes.

It is shown in Table I that these four varieties have produced very different amounts of fruit. Thus the average annual yields per bush for the four varieties Baldwin, Boskoop, Davison's Eight and Taylor are 3.2, 4.5, 2.0 and 1.6 lbs. respectively for the five years 1930-1934 inclusive. Assuming a planting distance of 6 × 6 feet (1,210 bushes per acre), the average yield per acre per year for the four varieties has been 3,872; 5,445; 2,420 and 1,935 lbs. respectively.

It is shown in Table I that the four varieties exhibit wide differences in picking costs per ton, assuming that the crops are picked at the uniform rate of sixpence per hour. These costs work out at £7 0s. 1d. and £5 15s. 5d. for the varieties Baldwin and Boskoop, and £7 18s. 7d. and £12 14s. 6d. for the varieties Davison's Eight and Taylor. The figures are the average costs for picking the crops during the five years 1930-1934.

A closer examination of the data given in Table I shows that the average picking costs per ton of fruit not only vary with the varieties, but that there is a variation within any variety from year to year. The data suggest that, for the varieties under consideration, the picking cost per ton of fruit shows an inverse relation to the yield, and that other things being equal, the higher the average yield per bush the lower will be the picking cost per ton of fruit.

B. Long Ashton Material.

The detailed data for this material are presented in Table II. The arrangement is similar to that of Table I, the varieties being Baldwin, Boskoop, French (Seabrook's Black) and Edina. These four varieties are the standard sorts intended to cover the normal black currant season.

The average picking costs per ton of fruit over the five year period 1930-1934 are as follows :—Baldwin £6 16s. 3d., Boskoop £6 2s. 6d., French £8 16s. 11d. and Edina £8 5s. 7d.

It is interesting to notice that for these four varieties there is not the wide range in picking costs that was shown for the four varieties in the Wisley material group. Similarly, the average yield per bush for the varieties in the Long Ashton trial does not vary so widely as in the Wisley experiment, the four varieties having an average yield of 3.0, 3.7, 3.8 and 3.5lbs. per bush respectively. It will be seen that the yield of the Boskoop and Baldwin bushes in this group of material is slightly less than that of the Wisley material, due probably to a slight difference in pruning method.

Attention is called to the very little difference in the average picking costs per ton of the two varieties Boskoop and Baldwin in the two trials. Thus, for Baldwin, the figures are £7 0s. 1d. and £6 16s. 3d. for the Wisley and Long Ashton material respectively, whilst for Boskoop they are £5 15s. 5d. and £6 2s. 6d. respectively. The closeness of the averages for each of these two varieties on the two plots suggests that varietal factors are important in determining picking costs and allows of discussion on this basis. In this group the picking costs do not show the inverse relationship to yields as in the Wisley group.

Discussion.

The main object of this paper is to discuss the part which picking costs play in determining the economic advantage of any variety. It has been mentioned that upon commercial fruit holdings this fruit is usually picked at a fixed price per lb., but this price is fixed in relation to the amount that can be earned in a given time and also in relation to the picking of other fruits such as raspberries and strawberries. In practice, the price paid for picking blackcurrants is usually fixed at a relatively high figure since the price for picking raspberries and strawberries must of necessity be a low one. Picking prices are therefore adjusted in a complementary way. A knowledge of the relative picking costs of the several blackcurrant varieties, therefore, is of considerable help in enabling the producer to fix a fair picking price.

Crop yield is obviously the most important consideration in any variety because the definitely low yielding sorts can never be so profitable as the higher yielding ones of the same season of ripening. Under Long Ashton conditions, it has been shown that the two varieties Davison's Eight and Taylor are not profitable sorts to plant because their yields are much too low by comparison with others of the same season of ripening ; it is also clear that Boskoop and French are the best varieties to grow so far as yield is concerned, Baldwin being a good third variety, although of a later season.

Of the varieties Boskoop and French, a decision as to which sort to plant is difficult to make, if it has to be based upon a consideration of yield only. In fact the choice cannot be made upon a basis of average yield because they are for practical purposes identical. The season of ripening is somewhat different and this may be the deciding factor in most cases.

A consideration of picking costs, however, enables the producer to make a decision which is based upon an estimated cost of production of the two sorts, and not only upon the yield. It must be obvious that in the end a variety which yields a light crop may be as profitable as another which yields a heavy crop if the production cost per ton of fruit is proportionately higher for the latter variety.

It has already been shown that the picking costs of the several varieties under discussion vary considerably, and it has also been pointed out that picking costs may be as much as 15 or even 20 per cent. of the gross selling price, and that in consequence it is an important item in the cost of production. It may not be out of place, therefore, to discuss the way in which picking costs and crop yield affect the economic value of any particular variety.

It is calculated from Table II that the variety Boskoop produces one ton of fruit for every 21 cwts. produced by French, and that it costs on an average £6 2s. 6d. per ton to pick the ton of Boskoop, but £9 5s. 11d. to pick the 21 cwts. of the variety French. The difference in picking cost, therefore, is a matter of £3 3s. 5d. in favour of Boskoop. In order to obtain equal returns per acre from these two varieties—assuming that other costs of production and the market value of the fruit is the same for both—it is necessary to sell the extra one cwt. of French black currants for a price in excess of £3 3s. 5d., which is the extra cost of picking this fruit. Thus, at a selling price of £3 3s. 5d. per cwt., or £63 5s. 4d. per ton, the gross returns per acre from these two varieties would be equal. At this price the smaller crop of Boskoop gives a finiancial return equal to that of the higher yielding French variety, because of its lower picking cost. It is clear that when the selling price of blackcurrants falls below this figure it is more profitable to grow Boskoop in spite of the slightly lower yield, whereas when the price rises above this figure, it is more profitable to grow French, assuming of course, that wage ratio remains constant. There would also be a small additional cost of carriage and baskets for the larger crop.

The relation of Baldwin to French may be studied in the same way It is shown in Table II that for every ton of fruit produced by Baldwin, French produces 26 cwts., and that the cost of picking these two sorts is £6 16s. 3d. for the one ton of Baldwin and £11 9s. 11d. for the 26 cwts. of French. In order to obtain equal returns per acre from these two varieties it is necessary to sell the 6 cwts. of French for £4 13s. 8d. or at the rate of 15s. 7d. per cwt. When, therefore, the price of blackcurrants is £15 11s. 8d. per ton the gross return from these two varieties is equal. Below this figure it is more profitable to grow Baldwin, whereas when above, it will pay better to grow French.

The two varieties Edina and French, and also Edina and Baldwin, can also be compared in a similar way.

Bearing in mind the assumptions made earlier in this paper that other production costs for all varieties are the same, that they have the same market value and that picking is paid for upon a time rate basis, it has been shown that yield must be considered in conjunction with picking costs in attempting to determine the economic value of a blackcurrant variety. Thus for any two varieties, one of which yields a better crop than the other but costs more per ton to pick, there is a certain figure at which the fruit must be sold in order to realize equal returns per acre. It is stressed that yield alone may be a very doubtful basis upon which to estimate the value of a soft fruit variety, and that in variety trials of soft fruit in particular, determination of picking costs should be made at the same time as yield averages are obtained if commercial advantages are to be assessed.

It is not intended at this point to discuss the above results any further, except to point out certain practical points. In the first place, emphasis must be laid upon the fact that these results were obtained under strictly controlled conditions at the Long Ashton Research Station. Culture and manuring have been carried out to the extent normally given to this crop, but have not been so generous as are given by many of the best growers of this fruit. Local conditions of soil and climate doubtless favour high yields of certain of the varieties and prejudice those of others. and thus growers must interpret these results with due regard to their own local conditions.

Attention is drawn to the fact that when selling prices are low the choice of a suitable variety to plant is made more difficult. Above a certain price, at the present level of wage ratio. certain varieties are the more profitable whereas below this figure others are likely to leave a better return per acre.

TABLE I.

WISLEY MATERIAL. SHOWING CROP WEIGHTS, TIME TAKEN TO PICK AND COST OF PICKING OVER FIVE CONSECUTIVE PICKING SEASONS.

CALCULATED FOR ONE PICKER.

Year.	No. of bushes.	Total crop weight in lbs.	Average crop weight per bush lbs.	Total time taken to pick in		Average time taken to pick one bush mins.	Time taken to pick one ton		Total cost of picking			Average cost of picking one bush pence	Cost of picking 1 ton at 6d. per hour		
				hrs.	mins.		hrs.	mins.	£	s.	d.		£	s.	d.
VARIETY : BALDWIN.															
1930	104	275.9	2.7	28	0	16.3	227	19		14	0	1.6	5	13	8
1931	104	363.0	3.5	35	45	20.6	220	36		17	11	2.1	5	10	4
1932	104	396.0	3.8	34	38	20.0	195	49		17	4	2.0	4	17	11
1933	104	297.3	2.9	51	20	29.6	386	23	1	5	8	3.0	9	13	2
1934	104	299.8	3.0	49	55	28.8	370	51	1	4	11½	2.9	9	5	5
Average over 5 years :		326.4	3.2	39	56	23.1	280	12	1	0	0	2.3	7	0	1
VARIETY : BOSKOOP.															
1930	104	203.8	2.0	19	30	11.2	214	6		9	9	1.1	5	7	1
1931	104	628.8	6.0	40	0	23.1	142	27	1	0	0	2.3	3	11	3
1932	104	626.5	6.0	67	40	38.2	241	56	1	13	10	3.8	6	1	0
1933	104	466.1	4.5	53	35	30.9	257	28	1	6	10	3.1	6	8	9
1934	104	416.7	4.0	55	24	31.9	297	43	1	7	8½	3.2	7	8	10
Average over 5 years :		468.4	4.5	47	14	27.1	230	44	1	3	8	2.7	5	15	5
VARIETY : DAVISON'S EIGHT.															
1930	103	91.5	.9	16	0	9.3	391	38		8	0	0.9	9	15	10
1931	103	118.8	1.2	16	15	9.5	306	25		8	2	1.0	7	13	3
1932	103	262.5	2.5	27	5	15.8	231	3		13	7	1.6	5	15	6
1933	103	258.6	2.5	39	35	23.1	342	51		19	10	2.3	8	11	5
1934	103	282.8	2.8	39	36	23.1	313	36		19	9½	2.3	7	16	9½
Average over 5 years :		202.8	2.0	27	42	16.2	317	7		13	11	1.6	7	18	7
VARIETY : TAYLOR.															
1930	104	120.8	1.2	18	0	10.4	332	42		9	0	1.0	8	6	4
1931	104	172.3	1.7	32	30	19.0	422	46		16	3	1.9	10	11	5
1932	104	182.8	1.8	36	40	21.1	449	3		18	4	2.1	11	4	6
1933	104	151.8	1.5	42	20	24.4	624	32	1	1	2	2.4	15	12	3
1934	104	191.3	1.8	61	3	35.2	714	52	1	10	6½	3.5	17	17	11
Average over 5 years :		163.8	1.6	38	7	22.0	508	47		19	1	2.2	12	14	6

TABLE II.

LONG ASHTON MATERIAL. SHOWING CROP WEIGHTS, TIME TAKEN TO PICK AND COST OF PICKING OVER FIVE CONSECUTIVE PICKING SEASONS. CALCULATED FOR ONE PICKER.

Year.	No. of bushes.	Total crop weight in lbs.	Average crop weight per bush lbs.	Total time taken to pick in		Average time taken to pick one bush mins.	Time taken to pick one ton		Total cost of picking			Average cost of picking one bush pence	Cost of picking one ton at 6d. per hour		
				hrs.	mins.		hrs.	mins.	£	s.	d.		£	s.	d.
VARIETY : BALDWIN.															
1930	184	607.9	3.3	58	0	18.9	213	46	1	9	0	1.9	5	6	11
1931	184	582.5	3.2	63	0	20.5	242	13	1	11	6	2.1	6	1	1
1932	184	623.4	3.4	54	10	17.7	194	38	1	7	1	1.8	4	17	4
1933	184	440.7	2.4	70	10	22.9	356	44	1	15	1	2.3	8	18	4
1934	184	519.2	2.8	82	20	26.8	355	12	2	1	2	2.7	8	17	7
Average over 5 years :		554.7	3.0	65	32	21.4	272	31	1	12	9	2.2	6	16	3
VARIETY : BOSKOOP.															
1930	184	381.6	2.1	35	0	11.4	205	28		17	6	1.1	5	2	9
1931	184	871.0	4.7	64	0	20.9	164	39	1	12	0	2.1	4	2	4
1932	184	723.7	3.9	90	45	29.6	280	53	2	5	4½	3.0	7	0	5
1933	184	682.9	3.7	86	55	28.3	288	6	2	3	6	2.8	7	4	1
1934	184	757.9	4.1	96	46	31.6	286	0	2	8	4½	3.2	7	3	0
Average over 5 years :		683.4	3.7	74	41	24.4	245	1	1	17	4	2.4	6	2	6
VARIETY : FRENCH.															
1930	192	377.4	2.0	56	0	17.5	332	20	1	8	0	1.8	8	6	2
1931	192	888.1	4.6	107	15	33.5	270	31	2	13	8	3.4	6	15	3
1932	192	856.4	4.5	135	0	42.2	353	11	3	7	6	4.2	8	16	7
1933	192	759.7	4.0	144	0	45.1	425	20	3	12	2	4.5	10	12	8
1934	192	708.8	3.7	122	43	38.3	387	48	3	1	4½	3.8	9	13	11
Average over 5 years :		718.1	3.8	113	00	35.3	353	50	2	16	7	3.5	8	16	11
VARIETY : EDINA.															
1930	184	471.9	2.6	63	0	20.5	298	58	1	11	6	2.1	7	9	6
1931	184	661.6	3.6	88	0	28.7	297	57	2	4	0	2.9	7	9	0
1932	184	764.0	4.2	87	20	28.5	255	57	2	3	8	2.9	6	8	0
1933	184	741.0	4.0	110	55	36.2	335	13	2	15	6	3.6	8	7	7
1934	184	799.6	4.3	166	20	54.2	467	48	4	3	2	5.4	11	13	11
Average over 5 years :		687.6	3.5	103	7	33.6	331	11	2	11	7	3.4	8	5	7

PROGRESS REPORT ON FRUIT BREEDING.

By G. T. SPINKS.

During the last two years comparatively few new seedlings have been raised. All the land at the Research Station available for seedling material is now fully occupied and it is only as sections are cleared of older seedlings that new families can be planted out. The existing seedlings and clone plants of selected seedlings have been kept under observation and a few more seedlings have been selected for propagation.

Apples.

Young trees of the new varieties Taunton Cross and Worcester Cross have borne good crops and the fruit has been satisfactory in appearance and flavour. The variety Plymouth Cross has also cropped well, but it now appears doubtful if this variety will reach the required standard of value to justify retention. Though a few people consider the fruit a good dessert apple the majority find it is much too acid. This variety is fairly susceptible to scab and is also liable to injury from lime sulphur ; in addition, it blooms very early, which is a disadvantage. The young trees of the other three new named varieties have borne such small crops up to the present that very little fresh information about them has been obtained.

Crops on seedling trees had been uniformly rather poor for the previous two seasons : but in 1934 fruit was obtained from about 130 trees. Some of these were members of young families such as Worcester Pearmain × Beauty of Bath, Worcester Pearmain × Rival, Worcester Pearmain × Charles Ross and Worcester Pearmain × Macintosh Red. About six new seedlings of possible value have been noted and a large number of older trees have been discarded.

A large family of plants was raised in 1933 from a cross made in the previous year between Taunton Cross and the cider variety Dabinett. The variety Dabinett was used as a parent on account of its consistently regular cropping habit, though, judging from the results obtained with earlier crosses in which one parent was a bitter-sweet variety, it seems likely that a high tannin content will be present in the fruits of many of its progeny.

A paper is now in course of preparation dealing with the inheritance of various characters in a number of the families of apple seedlings which have been grown at Long Ashton.

Pears.

The crop and quality of fruit borne on young trees of the new variety Bristol Cross have been satisfactory. Fruit of the 1934 crop of this variety, which is normally in season in mid-October, was kept in good condition in cold storage until the end of January 1935, though the flavour at that time was not as good as that of the unstored fruit in October.

Fruit has been obtained from about 40 seedling trees of which a number have now been discarded. One tree, a member of a family of Dr. Jules Guyot × Conference, produced mid-September fruit of very good quality and has been propagated.

Three large families of seedlings which have been standing in the nursery for several years have just been planted out. These consist of Bristol Cross × Comice, Seedling W.C.5 (Williams × Conference) × Comice, and Bristol Cross × W.C.5.

Cross-pollinations made in the last two years between various members of the family Williams × Conference with the object of obtaining early varieties have resulted in a very poor yield of seed.

Plums.

Young trees of the new variety Wye Cross, a very late cooking plum, bore fairly good crops in 1934. The other named varieties have not yet borne much fruit on the young trees. The variety Severn Cross, which is a good late dessert plum, now appears as though it may be rather susceptible to " silver-leaf," though none of the affected trees have yet died. Other selected, but un-named, seedling varieties have not yet carried any considerable crop on young trees.

Fruit was obtained from about 70 seedling trees in both 1933 and 1934. Many of these trees had fruited previously and a number have now been discarded. No fresh selections for propagation have been made.

Small numbers of young seedlings have just been planted out and others are still in the nursery. Seeds obtained during the last three years as the result of self-pollinating several selected seedlings, have given a very poor yield of plants. Apparently the best conditions for storage and germination of the seed have not been found.

Black Currants.

In 1933 crops, probably owing to spring frosts and the very dry weather later, were light on most of the varieties in the seedling variety trials plot. The early variety Mendip Cross, although the crop was rather below normal, gave a 50 per cent. heavier yield than Boskoop, on which the crop was normal. The later variety Cotswold Cross carried only half a normal crop but was equal to Baldwin, on which the crop was also light. In 1934 all varieties carried good crops. Mendip Cross gave double the crop of Boskoop and Cotswold Cross double the crop of Baldwin. For the first five years of cropping the relative weights of the total crops per bush of these four varieties over the whole period are :—

Baldwin (Herefordshire strain) ..	100
Boskoop	69
Mendip Cross	129
Cotswold Cross	144

Another trial plot, containing Mendip Cross, Cotswold Cross and five more promising but un-named seedling varieties from the older plot, was planted out at the end of 1933.

In 1934 five families of seedlings, containing altogether about 1,200 plants, carried their first full crop. These seedlings had been derived from a few previously selected seedlings by selfing or intercrossing, the object being to obtain heavy-cropping, early varieties. Observation showed that, with only a few exceptions, the crops and size of fruit were merely moderate, while very few of the plants were noticeably early. A noteworthy feature was the undesirable spreading or drooping habit of many of the bushes. Only five plants were thought to be worth propagating, but all will be observed for another year before being destroyed.

Gooseberries.

Although very little breeding of gooseberries has been attempted at Long Ashton, a few families of seedlings were raised some years ago. Several of these were propagated but, although quite good, most of them show no superiority over older sorts. One variety, however, may possibly be of value as a yellow dessert fruit, and is being propagated and tried still further. This arose from a cross between Whitesmith and Keepsake.

Raspberries.

It is thought that one seedling variety of raspberry which has compared very favourably with varieties now in commercial use may be worth naming and distributing, but for the present it is merely being grown for further observation.

The clones raised from seedlings selected from three families in 1931 and 1932 (see Annual Report 1932) have been kept under observation. Some of these are fulfilling their early promise while others seem to have deteriorated. Several clones have been attacked by mosaic disease and have been destroyed. The best of these seedling varieties will be included in the next trial of commercial varieties to be set out here.

Two families of seedlings (1) Viking × Preussen (about 350 plants), and (2) Viking × Brighton (about 30 plants), have borne their first crops in 1934. In general, the fruit was found to be rather late in season, round, bright in colour and rather soft. Possibly some plants will be worth propagating but at least another year's observation is necessary before the probable value of any of the seedlings can be estimated.

Blackberries.

In 1933, the blackberry Ashton Cross gave a crop about 33 per cent. heavier than that of the Himalaya berry. For the four years 1930-33, the total crop weight per bush was 50 per cent. heavier for Ashton Cross than for Himalaya. In 1934, the season appeared to favour Himalaya, as it bore a crop only slightly lighter than that of Ashton Cross. The berries of Himalaya during some parts of the picking season were superior in size and appearance, though inferior in flavour, to those of Ashton Cross. In that year the Himalaya also ripened a good picking of fruit three days earlier than Ashton Cross, and at the end of the season the berries of Himalaya ripened well, while large quantities of berries of Ashton Cross remained unpicked as they failed to ripen. These differences, however, had not appeared in previous years.

In 1934, it was also possible for the first time to compare Ashton Cross with the variety Black Diamond. The above remarks about Himalaya apply almost equally to Black Diamond, which bore a slightly heavier crop than Ashton Cross.

Ashton Cross and other seedling varieties obtained from the same family are all susceptible to the attacks of a " rust " fungus, *Kuehneola albida.* Pustules of fungus spores appear on the young shoots in the spring, and later in the season the leaves may be infected. At Long Ashton the leaf infection is never severe, and the vigour of the plants has apparently not been affected by the presence of the fungus. In some other localities leaf infection has been found to be really severe, though it is not known how far this has affected the vigour of the plants. Possibly this difference in susceptibility is due to different climatic or soil conditions. The fungus has not yet been found on the varieties Himalaya and Black Diamond.

Strawberries.

Trials of seedling varieties selected from families raised in the years 1929 to 1931 have been continued. Although many of these varieties have become unhealthy and weak, a few still retain their early vigour and health and are satisfactory in other respects. One, in particular, raised from the cross Tardive de Leopold × Royal Sovereign, seems very promising and is being propagated as rapidly as possible. This variety, in addition to being vigorous and healthy, bears good crops of early berries which are almost equal to those of Royal Sovereign in appearance and flavour.

About half the plants in a large family of seedlings, obtained by crossing Paxton with a very healthy variety of unknown name, bore their first crop in 1934. Although the plants had grown well the crop was very light and the fruit was generally of poor quality and too soft. Very few plants seemed worth propagating. The second half of this family will fruit in 1935.

Distribution of New Varieties.

The scheme for the distribution of new seedling varieties has now been in operation for four years and each year a few additional members have joined and have been supplied with material for propagating the new varieties. The black currants, blackberry and pear have been most in demand, while there have been fewer requests for apples and very few for plums. As all the material supplied was in the form of grafts, cuttings, etc., it has scarcely had time to reach the fruiting state yet and thus very few reports on the varieties distributed have been received.

STUDIES ON MATURITY OF FRUIT.

IV.—THE CATALASE AND OXIDASE ACTIVITY OF APPLES IN STORAGE AS AFFECTED BY CONDITIONS OBTAINING DURING GROWTH.

By J. C. HINTON.

INTRODUCTION.

The earlier papers in this series (Annual Report, Long Ashton, 1931) presented an outline of existing knowledge with respect to the maturation processes of fruits. This knowledge was interpreted as showing that maturation is essentially concerned with the breaking down of complex substances into simpler ones, starch and other polysaccharides yielding sugars, more complex sugars yielding simpler ones, cell wall compounds producing pectin which in turn decomposes, and proteins producing simpler nitrogenous bodies. These complex substances are formed during the period of development of the fruit and the change from the processes of their formation to the opposing processes of their breakdown appears to be smooth and continuous, there being no period of rest which can be recognised and defined as the mature stage. In fruits, as they are ripening on the tree, there is a gradual increase in the rate and in the importance of the breaking down processes, and when fruits are picked from the tree this gradually increasing rate is much accelerated as a result of the removal. The whole subject of maturity of fruits will be considered in more detail in a forthcoming general paper, but for the present purpose it can be stated that the importance of maturity of fruits to the industry of fruit growing lies in the fact that their behaviour after leaving the tree is greatly influenced by the balance which the two opposing processes mentioned have attained at the time the fruits are removed from the tree, and, in a secondary manner, at the time they are placed under changed conditions such, for example, as obtain in cold storage.

It was also suggested, as a working hypothesis, that any factor which tends to maintain the food supply—using this term in a very general sense—to the developing fruits would retard the development of the breaking down processes in the fruits, and in this way would retard maturation. At the same time, of course, such fruits would grow more rapidly, would be better developed, and on this account might appear to be riper. From the practical point of view, that is in their behaviour after picking, the balance of metabolism must be the true criterion.

The work to be described in Parts IV, V and VI of these studies was designed to make some comparison of the metabolism of fruits grown under conditions producing differential food supply, and at the same time to be a further contribution towards our knowledge of the effect of picking fruits at different stages on their subsequent metabolism. To this end three samples of apples were picked on different dates near to the normal picking date, (i) from trees which had been bark-ringed in the spring of the same year (ii), from trees growing under a grass cover crop, and (iii) from trees on which crop thinning had been carried out at a late date, compared in each case with controls growing under cultivation, not ringed and not thinned. The three factors represented by "grassing," "ringing," and thinning" have been shown to increase the food supply to fruits, apples growing under these conditions containing more sugar and solid matter in general than controls. (T. Wallace. Proc. 1st. Imperial Hort. Congress. 1930). If, however, the food supply is to have the suggested influence on the process of maturation, it must be maintained during the later development of the fruit, at the time when the breaking down processes are becoming important. For reasons which will be discussed immediately, it is inferred that this is the case with the three treatments included in these experiments.

The effect of the cultural practices of bark ringing and of growing under a grass cover is to depress the vegetative growth of the trees considerably. Observations made at Long Ashton show that this depressing factor is not acting uniformly throughout the growing season in the various treatments. Both treated and untreated trees make vegetative growth at nearly equal rates during the early part of the season ; in the "ringed" and "grassed" trees, however, the rate of growth decreases more rapidly than in the "not ringed" and "cultivated" trees, so that vegetative growth ceases considerably earlier in the former cases. In some seasons when the autumn is moist and warm, vegetative growth may continue slowly in the not ringed and cultivated trees during the whole of the time that the fruits are ripening ; whilst in the ringed and grassed trees growth has ceased some time before this. Vegetative growth imposes an additional drain on the food supplies of the tree and offers competition to the developing fruits in those cases where it continues. On the other hand, the food supply to the fruits of ringed and grassed trees should be maintained at a higher level.

To some extent therefore the factors "ringing" and "grassing" may be local and seasonal in effect, depending upon weather conditions being such as to maintain vegetative growth in the autumn in the untreated trees. The effect of thinning, obviously, is to decrease competition for the food supply from the time the thinning is carried out. In this case thinning was carried out when the second sample was picked, only one sample of thinned fruits being obtained. It would have been better to have had more than one sample, but the difficulty of getting a sufficient number of comparable trees prevented this. It will be realised that only one sample may be picked from each tree or else the factor of crop thinning will be introduced into each experiment. This difficulty also forced the experiments to be carried out on two varieties; Allington Pippin, at Long Ashton, was used in the "grass" and "thinning" experiments, and Newton Wonder, from a Herefordshire orchard, was used in the ringing experiments.

Two bushels of fruit were taken at each picking and kept in a common store. The temperature of this store was not controlled, falling from 12°C. to 2°C. between September and December. Thereafter there were fluctuations between 2°C. and 7°C. until the end of the experiments. This changing temperature must be taken into account when considering the results of the experiments, which show the behaviour of the various samples during storage. As indices of this behaviour the following factors, which themselves help to constitute the activity of the fruits, were considered in detail during the storage period :—

1. The catalase activity.
2. The oxidase activity.
3. The progress of softening.
4. The loss of total weight.
5. The total nitrogen content.
6. The reducing and non-reducing sugars.
7. The acid hydrolysable fraction.
8. The total solid content.
9. The acid content.

A summarised account of the work, containing the essential results, is presented in Parts IV, V and VI of these studies. The full account is filed in the records at the Long Ashton Research Station.

A. CATALASE.

Previous Investigations.

The important rôle which enzymes play in the physiology of plants and animals has led to a very considerable series of investigations into their relationship with various aspects of metabolism, particularly in the case of catalase.

An enquiry into the existing knowledge concerning catalase has been carried out and an account of this appears in the full version of this paper. From this enquiry it is clear that, in plants, changes in metabolism are followed closely by changes in catalase activity. At the same time it appears that the exact role of catalase in metabolism is still uncertain. In the present work, the changes in catalase have been examined in the fruits gathered from the differently treated trees, as an index to the changing metabolism of these fruits.

Published work relating to catalase in fruits is as follows :—

It was shown by Carrick that freezing apples for short periods, not exceeding three hours, increased slightly their catalase activity, but longer exposures of 20 hours reduced the catalase activity to a trace (3).

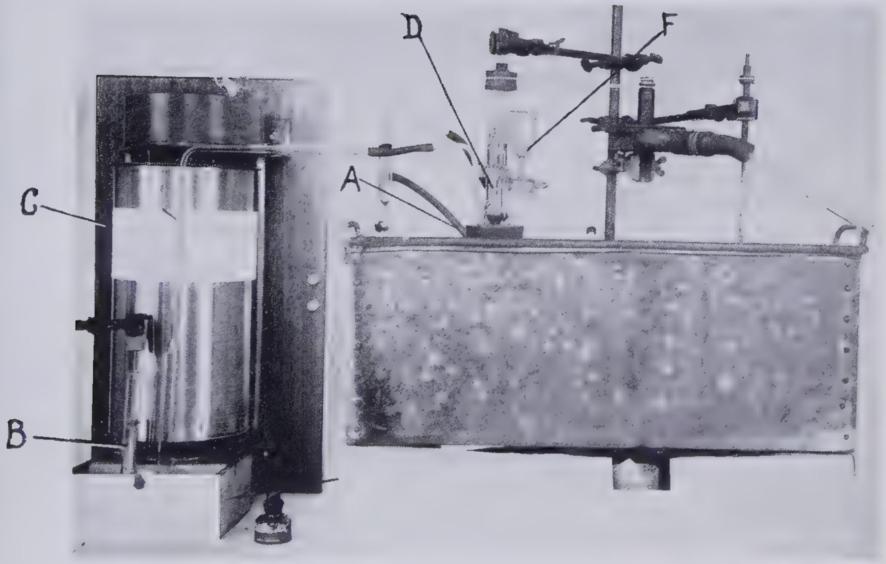
The temperature at which apples were stored was found by Drain (17) to have an effect on the catalase activity of apples, low temperatures depressing the activity. He also found that catalase activity was different in different varieties.

Magness and Burroughs (10), working with apples, Magness and Ballard (9) and Overholser (15), working with pears, showed that the catalase content of the fruits increased during the storage period, eventually declining. Magness and Burroughs also found that the higher storage temperatures increased respiration and metabolism in general, and increased the catalase activity of apples. The course of change of catalase in cold store was found by Harding (7) to be different in apples which were stored immediately on picking from that occurring in apples where there had been a delay between picking and storing. There was a rise in the catalase content during the delay which did not occur in fruit stored immediately. Upon being placed in cold storage, the catalase content of these delayed fruits decreased again, but the subsequent behaviour of the catalase was not the same as the control sample. Apples from trees which had been fertilised with nitrate were found to contain more catalase than fruits from unmanured trees.

Methods.

Becking and Hampton (1) have pointed out that the true measure of the catalytic power of an enzyme preparation is the time required to complete a given reaction, and the method used herein is based upon that described by them.

PLATE I.



APPARATUS FOR THE ESTIMATION OF CATALASE ACTIVITY.

A = Reaction Vessel (See Plate II) B = Manometer.
C = Recording Drum. D = Mercury Seal. F = Tap Funnel.

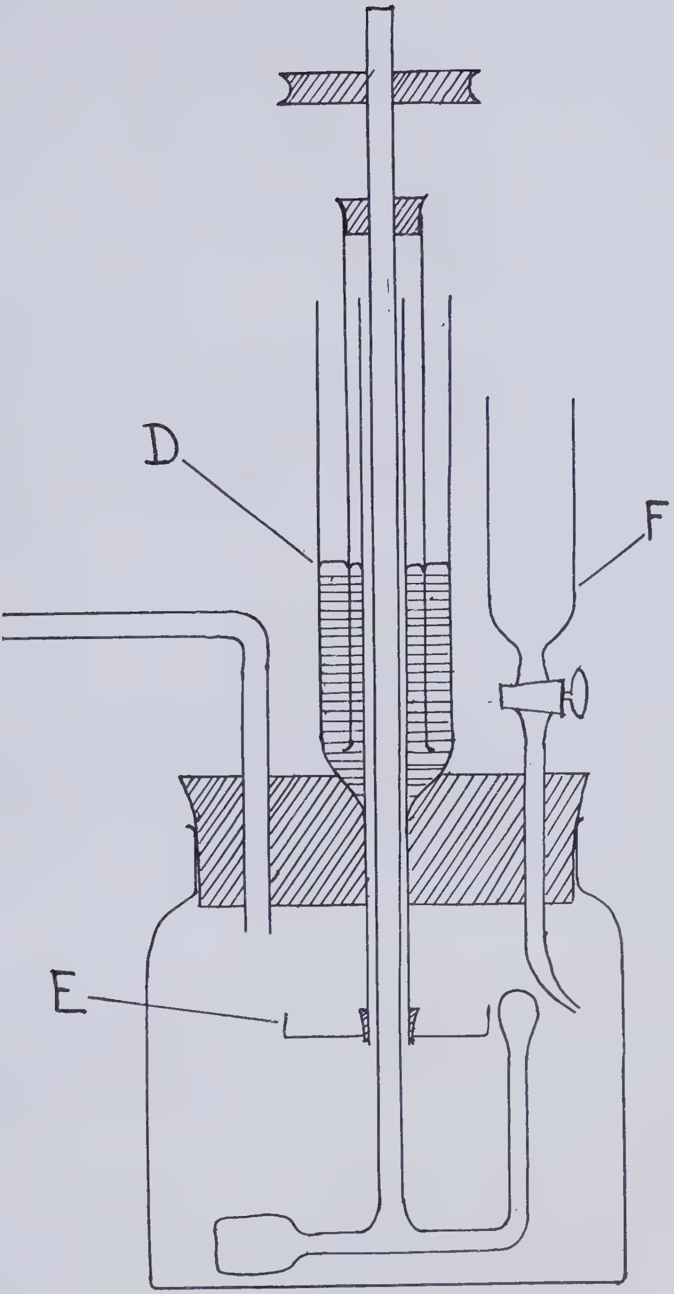


Plate II.

Reaction Vessel for Determination of Catalase Activity.

D. = Mercury Seal. E. = Dish Holding NaOH. F. = Tap Funnel.

Apparatus (Plates I and II). A closed reaction vessel, A, of approximately 300 ccs. was maintained at a constant temperature in a water bath, and was connected to the manometer B, which was arranged to record automatically on the recording-drum C. A stirrer was provided in the reaction vessel, passing through the mercury seal D and designed to agitate the air as well as the liquid in the vessel. A small porcelain dish E was suspended above the liquid, and contained NaOH solution (Plate II). A tap funnel F, permitted the addition of liquids.

Preparation of Material. 20 apples were taken as a representative sample for each estimation. As catalase is present in the skin in much greater amounts than in the flesh (5) and as thorough mixing of the skin with the flesh is very difficult, the skin and the core were removed and only the flesh used in making the sample. A section from the mid-portion of each apple was finely chopped and the whole thoroughly mixed together. Knott (8) has shown that such a composite sample is not as satisfactory as the mean of the figures obtained for each individual of the sample, being consistently high. Figures obtained on various composite samples, however, bear the same relation to one another as the means of the individuals in the samples, so that the comparative value of the figures will not be affected. As the figures were only to be used in a comparative way and as it would have been impossible to have taken the same number of samples if individuals had been estimated separately, the composite sample was used.

Mode of Procedure. 20 grs. of the mixed sample was ground immediately in a mortar for 3 minutes with 1.5 grms. of precipitated $CaCO_3$ and a definite quantity of washed silver sand. The pulp was transferred to the reaction vessel with 40 ccs. of a phosphate — KOH buffer of pH 7.0. 1 cc. of $\frac{N}{1}$ NaOH was placed in the small receptacle and the vessel placed in position. After 20 minutes, during which time the liquid was stirred constantly, no further changes in pressure, due to CO_2 absorption and temperature change, occurred. 3 cc. of hydrogen peroxide was then run in from the tap funnel, stirring being continued throughout, the zero point of the experiment being fixed at the moment of addition of the peroxide.

Method of Expressing Results.

3 cc. of hydrogen peroxide as used in each determination was found by experiment to liberate sufficient oxygen, when completely decomposed by an excess of catalase preparation, to raise the pressure inside the vessel equivalent to 2.7 inches of mercury.

This pressure of 2.7 inches therefore represents the point of complete reaction. In many of the actual determinations, it was impossible to determine with accuracy the time at which this point was reached on account of the very great slowing down in the rate of the reaction as it proceeds towards completion; moreover the nature of the reaction undergoes a change towards the end in this case, as will be discussed later. On this account the point of half reaction was used as the standard, equivalent to 1.35 inches of mercury. The time required to reach this point in the reaction was taken as t and the index of catalase activity became $\frac{1}{t}$.

It is to be noted that when the catalase activity of a number of samples is being compared under the same conditions, as is the case in the present series, the comparison becomes one of catalase content. A fixed amount of catalase, however, will exhibit different values of " activity " if estimated under different conditions. To avoid any confusion from the use of terms, the word activity will be used consistently in the present account.

Significance of Results.

The following factors which affect the catalase reaction have been considered in carrying out the determinations :—

(1) *pH and* (2) *Temperature.* Morgulis has demonstrated that these two factors are to some extent interdependent (12). Catalase is most reactive at pH 7.0 and 2°C. At higher temperatures there is some destruction of the catalase, this being more severe at lower pH values. The determinations herein recorded were carried out at 23°C. ± .05°C. at which some destruction would take place. All the catalase preparations were accordingly exposed to this temperature for the same length of time (20 minutes) before commencing the estimation. The figures are used as obtained for 23°C. and are not corrected to 2°C. as Morgulis has practised (13). The reaction of the liquid was maintained at pH 7.0, Parke-Davis hydrogen peroxide, which is stable at this reaction, being used.

(3) *Exposure of the Catalase Preparations to the action of Acid during Grinding.* From experiments carried out on the apple material, this appears to be a factor distinct from the hydrogen ion concentration of the reaction liquid. This is shown by the following results which are examples from those obtained from experiments with the apple material.

	Catalase Index $\frac{1}{t}$
1. $CaCO_3$ completely mixed before grinding	.2381 .2439
2. $CaCO_3$ imperfectly mixed before grinding ..	.2000
3. $CaCO_3$ added two minutes after grinding ..	.0295
4. $CaCO_3$ completely omitted	.00714

Thus, exposure of the enzyme to the fruit acid, even if this is neutralised after two minutes and the determination carried out at pH 7.0, destroys some of the activity under these conditions. This is in agreement with the results of Knott (8), who reports that absence of $CaCO_3$ depresses the catalase activity of a preparation even when the pH of the reacting liquid is subsequently adjusted to 7.0 by means of a buffer. His results indicated that the activity of the neutralised as compared with the unneutralised was as .17 to .10.

(4) *Time of Grinding.* The time of grinding of the material is well known to have some effect on the catalase activity, excessive grinding having a depressing action. The time of grinding and the amount of sand were standardised in the present work. Freezing the material to facilitate grinding was tried but abandoned, since on exposing the material to temperatures of about—10°C. for 12 hours the catalase activity was depressed to 25 per cent. of that of the unfrozen samples.

(5) *Agitation and Treatment of the Catalase Preparation before Estimation is Carried Out.* The many disturbing influences which have been effectively investigated by Knott (8) and others were eliminated by carrying out the determinations immediately after the preparation of the material.

(6) *Agitation of the Liquid during Estimation.* It is common experience that the amount of agitation given to the reacting liquids materially affects the result. In the apparatus used for these determinations, the speed of stirring was found to have an influence as follows :—

Approx. 100 revs. per minute ..	.1961
,, 200 ,, ,, ,, ..	.2222

The speed of stirring was maintained at 100 revs. per minute for all estimations.

(7) *Error of Sampling.* Duplicate samples from the mixed material were estimated in each case, and the mean of the two

taken. The error involved in mixing and weighing out 20 grs. from the bulk is shown by the following range of duplicates :—

.0537 .0574	.0793 .0793	.1176 .1316	.1923 .2083	.1613 .1667
.0218 .0204	.0885 .0885	.1316 .1389	.1515 .1587	.2857 .3030
	.2500 .2632	.1190 .1389		

(8) *Concentration of the Reactants.* Becking and Hampton have shown that the expression $\frac{1}{t}$ is a true measure of the amount of catalase present in a preparation, but Morgulis (11) has also shown that the relative concentration of the reactants affects the progress of the chemical reaction. Much excess of hydrogen peroxide seriously depresses the rate of reaction, the kinetics of which are not normal. As the amount of hydrogen peroxide is decreased, the reaction becomes bimolecular in type, and with further decrease in the concentration of peroxide it gradually becomes monomolecular.

Results based on the time of the reaction can only be strictly comparable when the kinetics of the reactions are alike. Since the amount of catalase contained in the samples dealt with varied over a fairly wide range, and since it was necessary to use the same quantity of hydrogen on each occasion in order to simplify the method and economise in time, the kinetics of typical reactions have been investigated by calculating the velocity coefficients at different stages in the reaction. The figures for three representative reactions are given :—

(1) Time of half reaction = 3.5. a. = 1.35 (inches Hg).

t	Pressure (x) inches Hg.	$K = \frac{1}{t} \log \frac{a}{a-x}$	Y.
1.9	.4	.184	.175
2.9	.6	.203	.196
3.9	.73	.200	.195
4.9	.85	.202	.198
6.9	1.0	.196	.193
8.9	1.12	.199	.195
10.9	1.20	.202	.200

(N.B.—The pressures recorded on the charts, which are used in these calculations, are half the actual pressures existing in the vessel owing to the use of a U-manometer.)

Under column Y is given the coefficient K as calculated for the time measured from the moment of addition of the peroxide. This point is dealt with below.

(2) Time of half reaction = 6.1 a. = 1.35 (inches Hg).

t	Pressure (x) inches Hg.	$K = \frac{1}{t} \log \frac{a}{a-x}$	Y.
1.4	.2	.112	.0785
3.4	.5	136	.116
5.4	.7	.136	.122
7.4	.85	.134	.124
9.4	.95	.129	.121
13.4	1.05	.112	.108
21.4	1.21	.106	.103
40.4	1.30	.081	.0807

The monomolecular equation has been used in calculating these two examples, and the agreement is good as far as the time of half reaction.

(3) Time of half reaction = 22. a. = 1.35 (inches Hg).

t	Pressure (x)	$K = \frac{1}{t} \frac{\sqrt{a}-\sqrt{a-x}}{\sqrt{a}\,(a-x)}$	Y.
3.2	.18	.0198	.0159
7.2	.36	.0199	.0180
11.2	.50	.0199	.0186
15.2	.60	.0192	.0182
21.2	.70	.0178	.0172
29.2	.80	.0166	.0162
38.2	.90	.0164	.0161
80.2	1.10	.0142	.0140
110.2	1.20	.0156	.0155

The equation for a one and a half molecular reaction has been used in this case and the agreement so far as the point of half reaction is reasonably good.

In case (2) and (3) the rate of reaction does not agree well with the equation used after the point of half reaction, and this involves a matter of some interest.

Morgulis found that when hydrogen peroxide was in appreciable excess of the catalase, the reaction ceased at a point represented by the amount of catalase, some of the hydrogen peroxide remaining undecomposed, and that the kinetics of the reaction were correlated approximately with the relative amount of hydrogen peroxide decomposed. Thus, if 90 per cent. of the H_2O_2 were decomposed, the reaction was monomolecular; if 70 per cent. only were decomposed, the reaction was bimolecular. Northrop (14) in a re-examination of Morgulis' data finds that when the amount of hyrogen peroxide decomposed, *i.e.* truly entering into the reaction, is taken as "a," the reaction in all the cases cited by Morgulis are expressed by the monomolecular equation and are therefore of the same nature.

In the present series of experiments, however, the reaction appears to continue until all the hydrogen peroxide is decomposed, irrespective of the amount of catalase present in the mixture. In those cases where the peroxide is obviously in appreciable excess, the rate of the reaction is very slow and decreases continuously and smoothly as the peroxide is progressively decomposed. Towards the end, in these cases, it is only from an inspection of the continuous record obtained that the reaction is detected (see Plate III). It is possible that spontaneous decomposition of the hydrogen peroxide may be taking place to some extent, but when subjected to identical conditions with only the omission of the apple material, the extent of the spontaneous decomposition was insufficient to be recorded by the apparatus.

Under the conditions of this series of estimations, therefore, Northrop's modifications cannot apply, and it must be assumed that there is a variation in the nature of the reaction dependent upon the relative amounts of the reactants according to Morgulis' original suggestion. The change in the kinetic nature of the reaction towards the end in cases (2) and (3) indicated above may therefore be due to the changing relative concentrations of hydrogen peroxide and catalase when the peroxide is in slight excess. Time did not permit any further elucidation of this point.

The reaction in all cases has been characterised by a delay period at the commencement between adding the hydrogen peroxide and the evolution of oxygen, as has been experienced by Becking and Hampton and others. This delay period was inversely proportional to the speed of the reaction, being less in the case of the faster reactions. In calculating the coefficients of the reactions, it was found that good agreement was not obtained unless the time was measured as from the first signs of the reaction and not from the moment of addition of the peroxide, that is neglecting the delay period. The coefficients obtained when the delay period is included are given in column Y.

The reactions are considered to be sufficiently comparable, and the figures obtained, as set out below, to be highly significant.

Results.

The figures representing $\frac{1}{t}$, the catalase activity in storage, are presented in Figs. 2 to 13 and in Table I, the latter showing differences in rates of change.

Discussion of Results.

The results obtained from the experiment with the variety Newton Wonder, " ringed " and " not ringed " are more readily discussed in detail than are those from the variety Allington Pippin. This is in keeping with past experience, apples of the " late " type always yielding smoother results, possibly due in part to a smaller sampling error, but largely to the fact that their slower metabolism makes them less ready to respond to fluctuating external influences.

There are, however, one or two points to be observed in all the samples. The catalase activity rises as the storage period progresses but at the end of the experiment in three cases begins to decrease. One of these three, the Allington " not thinned " sample, was obviously very near the end of its life, more so than the other samples, being very soft and wilted and with a much discoloured skin. The two Newton samples were not markedly different from the others, but all of this variety were nearing the end of storage life, core-flush becoming evident at the time the experiment was concluded. It seems likely that towards the end of storage life the catalase activity tends to decrease in the apples used in these experiments.

There is also a difference between each pick in the initial activity, *i.e.* the activity of the first sample taken. It was not possible on this occasion to take the first sample immediately on picking, so that the initial activity is not that of the samples on the tree at the time of picking. This fact, however, is probably not sufficient to account fully for the fall in initial activity between the 1st and 2nd picks seen in all the experiments. The general level of the curves (Figs. 3 and 6) for the Allington experiments is also low in the 2nd pick ; this and the low initial activity is contrary to what would have been expected having regard to the course of change after picking. It cannot be explained at present, but since it occurs in experiments in two widely separated orchards, some climatic factor is suggested. For 4 or 5 days between the 1st and 2nd picks there was, at Long Ashton, a marked fall in temperature of 10° to 15°F. with easterly winds and ground temperatures approaching freezing point at night. Exact observations are not available for the Hereford locality, but it is certain that a change of this character would extend to this area also. This cold spell, which is probably responsible for the fall in catalase activity between the first two picks, was followed by a warm period between the 2nd and 3rd picks.

Examining now the " ringed " and " not ringed " experiment in more detail, it becomes apparent that little more is to be gained from the figures representing catalase activity alone. It is considered, as a general principle, that it will be more significant to study the *course of change* of catalase activity, rather than the activity itself at a given time. The catalase activity at any given time is the result of an equilibrium between the rate of formation of the enzyme and the rate of its use and destruction, and to this extent the figure obtained in a catalase estimation is a true representation of the activity of the organism with regard to catalase. But the relation of the catalase activity to the other activities of the organism will probably be more readily discovered by comparing the *changes* in catalase, rather than the catalase itself, with these other activities.

The rates at which the catalase activity is changing have been calculated and are presented in Table I. Those for the Newton experiment are presented in graph form in Figs. 11, 12 and 13. The exceptional rise during the early part of storage in the " not ringed " 1st pick, and again during the latter part of storage in the not ringed 2nd pick—the significance of which is not seen at the present time—complicates to some extent the story of events. Bearing in mind these exceptions, however, the following general interpretation is advanced.

The rate of increase of catalase is highest during the early part of storage, and falls more or less rapidly during the storage period. The fall is proportionate to the value of the maximum early rate, being more rapid in those cases where the early rate is higher. The differences between samples picked at different dates are seen to be of this nature, the later the date of picking, the higher being the early rate of increase, and the steeper the subsequent fall in rate. Thus the further developed and the more mature the fruits are when picked, the greater the early rate, and the more rapid the subsequent fall in rate of increase of catalase. Using this as a criterion it would seem, from an examination of Figs. 12 and 13, that the " not ringed " fruits are more mature than the ringed at the 2nd and 3rd picks ; the rate of change of catalase is higher, and the immediate fall in rate is steeper in the former in each case.

TABLE I.

RATE* OF CHANGE OF CATALASE ACTIVITY OF APPLES DURING STORAGE.

Rate of Change between Samples No.	Length of Time in Storage between Samples. Days.						Variety Allington Pippin										Variety Newton Wonder						
							A Cultivated			B Grass			C Not Thinned			D Thinned	E Not Ringed			F Ringed		
	A	B	C	D	E	F	1st Pick	2nd Pick	3rd Pick	1st Pick	2nd Pick	3rd Pick	1st Pick	2nd Pick	3rd Pick	3rd Pick	1st Pick	2nd Pick	3rd Pick	1st Pick	2nd Pick	3rd Pick
1	—	—	9	—	36	34	—	—	—	—	—	—	15.0	—	—	—	16.1	—	—	21.9	—	—
and	20	22	22	—	52	50	—	55.3	—	—	39.1	—	—	49.0	—	—	—	46.5	—	—	41.9	—
2	24	26	18	18	36	35	—	—	30.4	—	—	44.5	—	—	110.0	62.5	—	—	52.8	—	—	46.6
2	33	32	28	—	43	43	42.7	—	—	42.6	—	—	53.0	—	—	—	26.5	—	—	11.56	—	—
and	35	34	36	—	82	84	—	9.03	—	—	20.7	—	—	17.0	—	—	—	11.0	—	—	16.3	—
3	25	23	27	23	78	80	—	—	42.0	—	—	5.52	—	—	20.5	27.8	—	—	13.4	—	—	16.14
3	50	43	68	—	63	66	18.8	—	—	8.77	—	—	12.3	—	—	—	9.27	—	—	7.2	—	—
and	51	49	42	—	61	59	—	14.1	—	—	−1.31	—	—	−6.5	—	—	—	14.3	—	—	3.75	—
4	43	45	46	52	47	47	—	—	3.95	—	—	−6.75	—	—	− 4.4	−7.0	—	—	−7.23	—	—	−7.34
4	54	61	40	—	—	—	12.0	—	—	12.8	—	—	10.9	—	—	—	—	—	—	—	—	—
and	35	35	46	—	—	—	—	6.33	—	—	1.78	—	—	15.6	—	—	—	—	—	—	—	—
5	51	49	53	49	—	—	—	—	19.7	—	—	16.7	—	—	20.1	14.3	—	—	—	—	—	—
5	28	28	28	—	—	—	17.3	—	—	17.6	—	—	16.4	—	—	—	—	—	—	—	—	—
and	28	29	27	—	—	—	—	5.83	—	—	7.5	—	—	−36.0	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* The rates given in the table = the rates of change of the catalase index, $\frac{1}{t}$ per day multiplied by 10^4.

The figures representing rates of interest, of course, are expressions of the slope of the curves represented in Figs. 8, 9 and 10. Considering figs. 9 and 10 it is seen that the initial value of the catalase has increased between the two picks, and the two figures can be combined in the following way :—(Figure 1.)

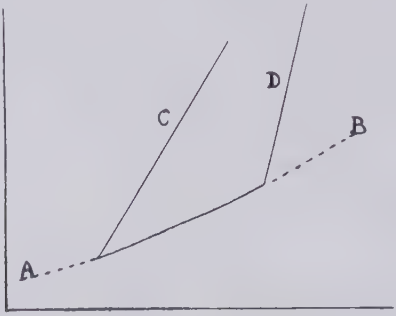


Fig. 1.

Such a diagram can be applied to other characteristics of ripening fruits, in particular the rate of respiration and the progress of softening. As has already been indicated in Part I of these studies it represents, by the curve AB, the increasing value, during the later development on the tree, of any of the various factors which together constitute ripening of fruits. After removal from the tree the progress of these factors, that is of ripening, is much enhanced, this being represented by the rapid rise along the curves C and D, *i.e.* Figs. 9 and 10. Furthermore, the degree of this enhancement, which is represented by the slopes of the curves C and D or Figs. 9 and 10, that is the rate of increase, is greater when the fruits have reached a more advanced stage in their development when they are removed from the tree, which is shown by comparing D with C. These points have so far been completely illustrated by the catalase figures already discussed.

The further possibility arises that it may be useful to know the relationship between the value of the curves C and D and the value of their corresponding points on the main curve AB. That will mean a relationship between the early rate of catalase increase in storage, and the catalase activity at the commencement of storage. Such a figure would be called a " relative rate " and might be useful in the following manner. The absolute values lying on the curves AB, C and D may vary in fruits from different trees, and even in different samples from the same tree, and yet may bear the same relation to one another. This is particularly likely in the case of catalase, where the vegetative vigour and other conditions of the tree are reflected in the catalase activity of the fruit. In these experiments it was necessary to take each sample from a different tree, and the use of a relative rate it is suggested may overcome variation in material from this cause. The following are the relative rates for the series :—

	1st Pick.	*2nd Pick.*	*3rd Pick.*
Ringed	263 (100)	595	395 (150)
Not Ringed ..	286 (100)	1086	464 (162)

It can be seen that the relative rate is a ratio of $\frac{\text{Rate}}{\text{Amount}}$; therefore the decrease in amount which occurred between 2nd and 3rd picks and which is thought to be abnormal, seriously interferes with the figures for the 2nd pick. It may be better on this account to consider only the figures for the 1st and 3rd picks. The relative rate has increased between these picks, meaning that " rate " is increasing more rapidly than " amount." Expressed as a per cent. figure the ringed has increased to 150 and the not ringed to 162, this being in agreement with the suggestion that the not ringed sample is maturing more rapidly.

It will not be profitable to discuss the results from the Allington series in detail, largely on account of the decrease in catalase activity during one period of storage which occurs in some of the series—six out of the ten—and which disturbs the course of the curves (at period approximately 100 days in Figs, 3, 4, 6 and 7). This decrease in activity may be due to the drop in storage temperature which took place gradually from the commencement and reached its low point some 10 days before the loss in catalase was detected. At the same time, however, four series of the Allingtons (Figs. 2, 3 and 5), together with the Newtons, all of which were under the same conditions showed no fall in catalase at this time. The fact that the decrease is seen in all four series of the 3rd pick and not at all in the 1st pick suggests that some significance attaches to it. What this may be, as also the significance of the fall in catalase during the first few days of storage in the case of the 1st pick must remain unexplained. This question could well be re-examined, with the course of events followed in more detail than was possible on the present occasion. The early part of storage in particular in the case of the Allingtons would seem to warrant more detailed examination for the purpose of the present study.

The curves of the rate of increase for the Allington series are not reproduced since no consistency is found in the details. The same general trend as was found in the Newtons is observable, however, *i.e.* for the early rate to be higher and the fall in rate to be more rapid with the later picks (as can be seen from Table I). The uneven nature of the curves prevents any interpretation along lines pertaining to the maturity of the fruits from grass and cultivated conditions. The values for the relative rates, however, exhibit a similar relationship as was found in the Newton experiment.

	1st Pick.	*2nd Pick.*	*3rd Pick.*
Grass	19.5	26.9	6.3
Cultivated ..	19.9	45.5	4.9
Thinned	–	–	16.2
Not Thinned ..	10.7	27.2	16.6

The rise between 1st and 2nd picks and fall between 2nd and 3rd picks is again present, but in addition the change between 1st and 3rd picks is represented by a fall in value in the case of the grass and cultivated series, whereas in the Newton series, as in the thinned series of the Allingtons, this change between 1st and 3rd picks is represented by a rise in value. Further investigation is necessary before the figures for the Allington series can be interpreted with confidence.

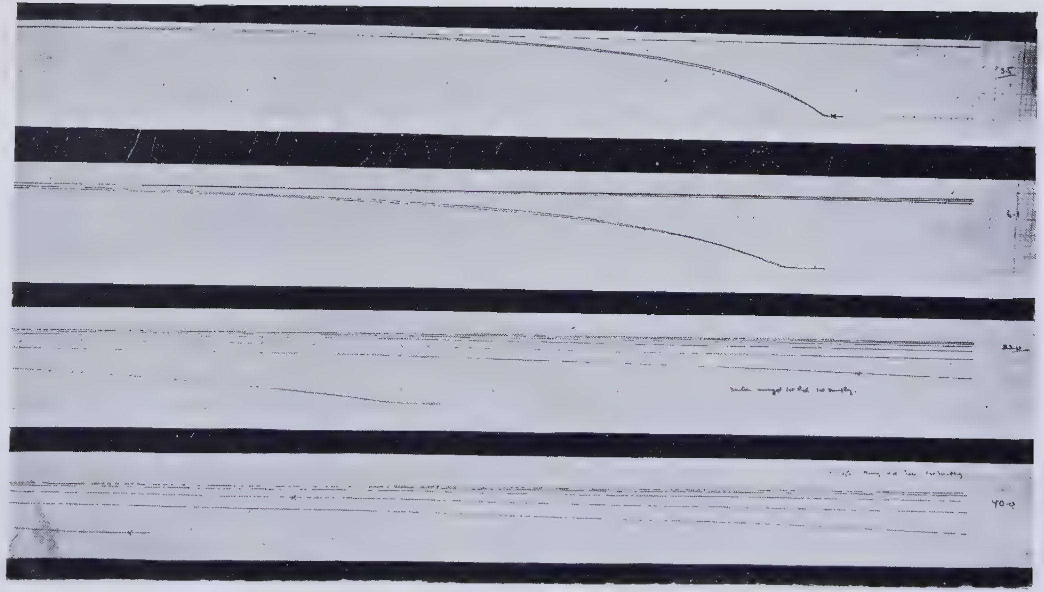


PLATE III.

SPECIMEN CHARTS FROM WHICH REACTION TIME IS OBTAINED.

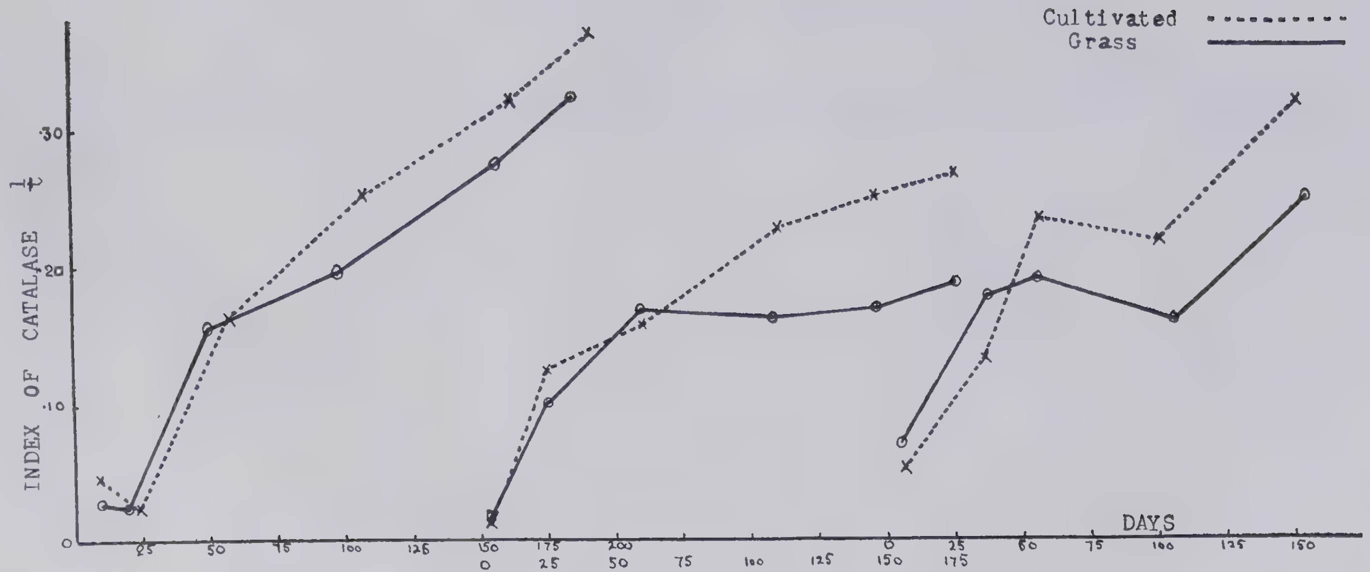


Fig. 2.
1st Pick.

Fig. 3.
2nd Pick.

Fig. 4.
3rd Pick.

Allington Pippin Grass and Cultivated.
Change of Catalase Activity in Storage.

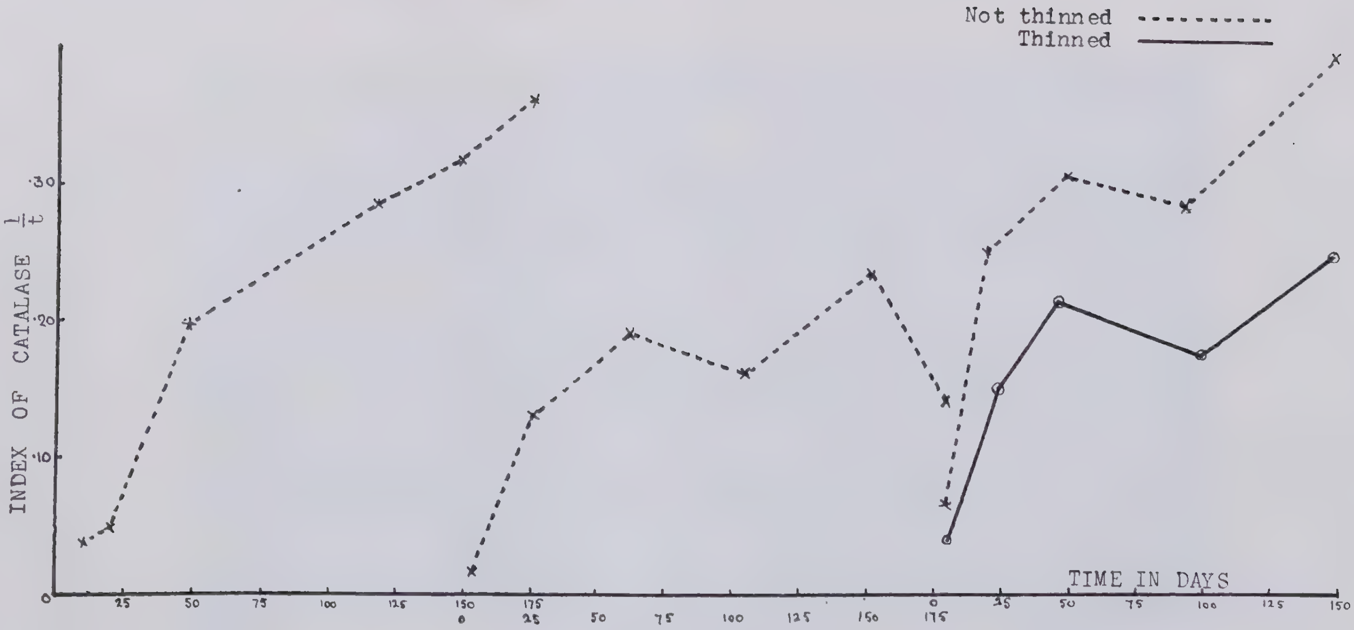


Fig. 5.
1st Pick.

Fig. 6.
2nd Pick.

Fig. 7.
3rd Pick.

Allington Pippin. Thinning Experiment.
Change of Catalase Activity during Storage.

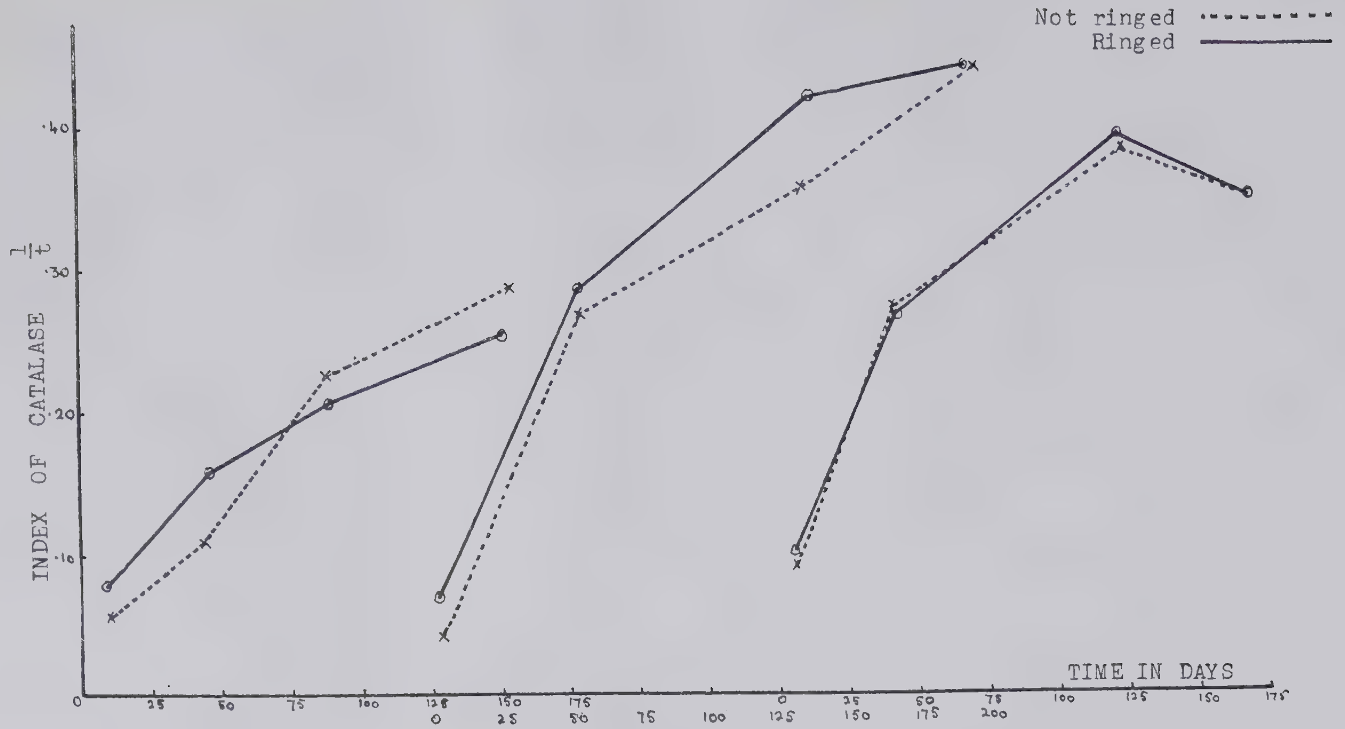


FIG. 8.
1ST PICK.

FIG. 9.
2ND PICK.

FIG. 10.
3RD PICK.

NEWTON WONDER. RINGING EXPERIMENT.
Change of Catalase Activity in Storage.

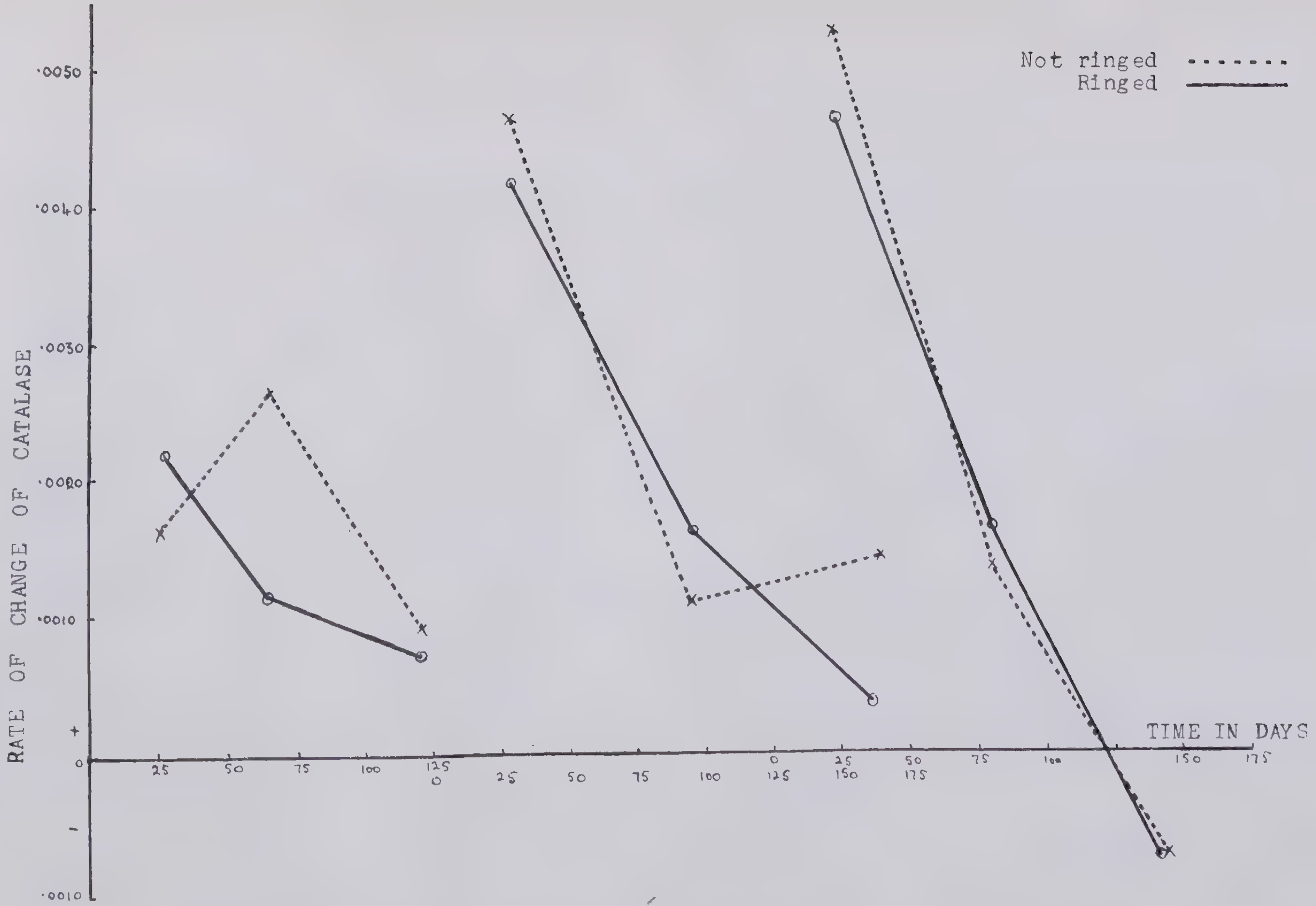


Fig. 11.
1st Pick.

Fig. 12.
2nd Pick.

Fig. 13.
3rd Pick.

Newton Wonder. Ringing Experiment.

B. OXIDASES.

Published work relating to oxidases in fruits is as follows :—

Drain (4) working with a number of varieties of apples showed that the distribution of oxidases in the fruit was localised, and that the distribution was slightly different in different varieties. Most activity was nearly always found in the core region.

Drain (5) and Haber (6) found that the oxidase activity of fruits of apple and tomato changed during the ripening processes, being greatest in fruits which were completely ripe, while Thatcher (16) states that oxidases are the only enzymes at all correlated with the ripening processes of apples, though he gave no indication in which direction the correlation lies. (Catalase was not included in these researches).

It was hoped that quantitative results would be obtained on the apple material as used in the catalase work by modifying Bunzell's oxidase method and making use of the apparatus already described. Reliable quantitative results, however, have not been obtained.

A summary of this section of the work is given below.

Methods.

The method used by Bunzell (2) depends upon the manometric measurement of the oxygen absorption, in a clossed vessel, during the interaction of oxidases and phenolic reducing substances such as quinol and pyrogallol. Thus only enzymes which are capable of activating the reaction with atmospheric oxygen are measured by this method, peroxidases, which are very probably also present in the apple material, being ignored. Time would not allow of any attempt to include this latter group.

50 grs. of the mixed apple material as prepared for the catalase determinations was ground in a mortar with 3 grs. of precipitated $CaCO_3$ and a measured quantity of clean silver sand. The ground pulp was transferred to the reaction vessel with 50 ccs. of phosphate buffer of pH 7.0, and 2 ccs. of N/1 NaOH solution was placed in the small dish to absorb CO_2. After having remained in the bath at 23°C. for 30 minutes without stirring, by which time temperature changes had ceased, 5 ccs. of 1 per cent. pyrogallol solution in water was run in from the tap funnel and stirring commenced. The reaction was allowed to continue until completed, the change in pressure, which in this case was negative, being recorded on the drum as before.

Bunzell has investigated the precautions necessary in carrying out this method and all of these were strictly observed in the present case. Nevertheless the method has not proved to be entirely satisfactory in application to the investigation of apple oxidases. The reaction was very slow, in many cases six hours being necessary for completion. The end point was also very difficult to fix, as under the conditions of the estimation there was an appreciable spontaneous oxidation of the pyrogallol into which the oxidase reaction gradually merged towards its completion. It is thought that a higher temperature and a slightly greater hydrogen ion concentration might improve the method as applied to the apple material.

Results.

Under these conditions significant figures representing differences between apples of one treatment and another could not be obtained. It is quite apparent, however, that the oxidase activity of all samples decreased during storage, and in some samples there was eventually a rise in activity towards the end of storage. During ripening on the tree there is also a decrease in activity. The fall during storage was more rapid in the variety Allington Pippin than in the Newton Wonder, though the initial activity and the fall in activity during ripening on the tree was about the same in the two varieties.

The following values illustrate the extent of the differences obtained in oxidase activity :—

	Allington Pippin. Storage.		*Newton Wonder. Storage.*	
	Commencement.	*End.*	*Commencement.*	*End.*
1st pick ..	20.0	6.0	20.0	10.0
2nd pick ..	14.0	5.0	14.0	9.0
3rd pick ..	14.0	4.0	15.0	9.0

The activity as measured in these determinations was closely paralleled by the extent to which browning of the tissues occurred during the cutting and mixing of the apples.

Though no conclusions as to the effects which the cultural treatments have had upon the oxidase activity are drawn from the figures obtained, it has become apparent that differences between treatments are present, and further work to develop a more suitable method would be amply repaid.

SUMMARY AND CONCLUSIONS.

A. Catalase.

From a survey of the literature it is evident that the catalase activity of plants is closely connected with their state of metabolism, and therefore that changes in the catalase activity of stored and ripening apples can be examined as indices of the metabolism of such apples.

The results of catalase estimations discussed in this paper are shown to be very satisfactory for the comparative nature of the work in hand.

Catalase activity of stored apples increased during storage, but in three cases, in the later stages, it subsequently decreased.

The exact nature of the change in catalase activity during storage is different in apples picked at different stages of maturity and in apples grown under different treatments.

In the case of Newton Wonder, differences in the rate of change of catalase during storage are such as to suggest that fruits on ringed trees are maturing more slowly than fruits from similar not ringed trees.

In Allington Pippin (1) grown under grass, (2) grown under clean cultivation, and (3) on which fruit thinning has been carried out, changes in catalase activity during storage were not sufficiently uniform to suggest differences in the rates of maturation of the fruits in these three groups. Significant changes probably take place at an earlier period in the storage life of fruits of this variety than was studied in detail in this investigation.

The low catalase activity of samples of fruits picked on one occasion was thought to be due to unusually low temperatures prevailing for some days prior to picking the samples.

B. Oxidases.

Estimations of the activity of the oxidase system were carried out on the same fruits used in the catalase estimations.

Oxidase activity of apples decreases markedly but slowly during storage and also during ripening on the tree.

Differences in the change in oxidase activity were present in fruits picked at different stages of maturity and grown under different conditions, but further work is required to elucidate the full nature of these differences.

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The above is an abridged list of references, containing only those mentioned in the summarised version.

STUDIES ON MATURITY OF FRUIT.

V.—THE EFFECT OF CONDITIONS DURING GROWTH ON THE PROGRESS OF SOFTENING AND ON THE LOSS OF TOTAL WEIGHT IN APPLES DURING STORAGE.

By J. C. HINTON.

A. PROGRESS OF SOFTENING.

Introduction.

The determination of hardness, carried out by means of the "pressure tester" is now widely advised in some countries as a practical means of determining the picking time of fruits. Originally devised in its application to pears (6, 8, 11, 14), it has since been extended to peaches (2, 13), plums (1), and cherries (7). It has never been found to be a success when applied to apples, however, because in this case softening takes place slowly during ripening and does not progress evenly, factors which vitiate the success of the test. Nevertheless a very considerable amount of softening takes place after picking during the storage of apples, and as a means of investigating the storage behaviour the pressure test can be of great use (4, 6, 15, 16).

Softening of the flesh takes place during the ripening of all fruits, and is essentially the result of changes occurring in the substance of the cell walls. It is not possible to make an exact statement as to the nature of these changes, but it is known that in part they are concerned with the middle lamella, the original wall deposited during the earliest stages of cell division, and having the function, in the older tissue, of holding together the mature cells. This middle lamella is largely composed of pectic substances and during ripening decomposition of these substances takes place, the pectin which is produced being subsequently decomposed to simpler compounds. The effect of this process on the middle lamella of fruits has been investigated recently in detail by Carré and Horne (3). The middle lamella, changing as it does, allows the individual cells to separate one from another, the extreme case of which is seen in the "mealy" fruit in which almost every cell of the flesh has become separated from its neighbour. This process alone will obviously greatly affect the resistance of the flesh to pressure ; at the same time it is very probable that changes of an analogous nature are progressing in the cell walls proper of the ripening fruit. Walls of the cells of ripe fruits have been observed by the writer to be thinner than those of relatively unripe fruits. The increase in size of the cells of fruits as they ripen, the extreme case of which is again seen in " mealiness " where the increase in size is often sufficient to burst the fruit, is proof of a decreasing resistance to pressure of the cell walls. Both of these factors—cells which more readily come apart, and walls which are thinner and more readily torn—combine to make a tissue which more readily disintegrates and offers less resistance to pressure.

Each of these factors is obviously a function of the metabolism of the fruit and may possibly be changed by influences which change the general metabolism. It is possible therefore that the changes in hardness of fruits may be studied as being an index to the metabolism of such fruits. Many observations can be drawn from the literature which support such a suggestion, examples being as under :—

Storage conditions affect the progress of softening of apples and pears, higher temperatures in particular increasing the rate of softening (9, 10, 12).

Under the same storage conditions, the amount of softening of apples and pears is, in general, observed to vary from one sample to another of the same variety. This is seen to most advantage in fruits which have been picked at different stages of ripeness, the riper fruits, *i.e.* the later picked fruits, softening more rapidly in storage than the earlier picked ones (12, 13, 15). This is due in part to the disappearance of a delay period at the commencement in which softening takes place slowly and in part to an increase in the rate of softening.

The coating of apples with oil and wax, treatments which affect the respiration, have been found, in some cases, to retard the softening during storage (9, 10).

These various factors, which have been found to influence the softening of fruits, have also been found on other occasions to influence such factors in metabolism as the rate of respiration. On one occasion the change in softening and in respiration rate as a result of changed conditions were correlated in the same sample of apples (10). It has also been shown that there is a decrease in insoluble pectin during the storage of apples, and by varying the conditions of storage, the amount of this decrease has been correlated with the amount of softening (5).

It would thus appear possible to use and study the progress of softening of fruits, particularly of apples, as an index to their metabolism, and it is in this way that it has been applied in the present work.

Factors Affecting the Pressure Test.

Before proceeding to describe the work which has been done along these lines, it will be advisable to discuss the factors which can affect the results from the pressure test and which need to be carefully considered. Most obvious of these is the presence of scars or other deformed portions due to damage in the early stages of growth and which increases the hardness of the flesh for some distance around the actual scar. This is caused by the cells in this region being poorly developed, small, and possessed of thick walls. For similar reasons, the portions near the stalk and the calyx are harder than the mid-portions of the fruit, and smaller fruits are harder than larger, better developed ones. Similarly, the increase in hardness which accompanies the deeper redness of the skin of the exposed side is due to the thicker walls of the cells of the flesh under the redder portions of the skin. These factors are readily taken account of during the carrying out of the test, only the mid portions of the fruit being tested, deformities being avoided, and an equal number of tests being made on red and green portions of fruits of comparable sizes on each occasion that the test is applied.

The turgidity of the fruit, however, is a factor that cannot be eliminated in storage studies, and which must be taken into account in the consideration of results. The hardness of fruits is measured in the pressure test by noting the pressure required to force a plunger a given distance into the flesh of the fruit. The action of the plunger is to tear apart the tissues, partly by separating the individual cells, and partly by rupturing the cells themselves. It is obvious that cells which are fully distended and turgid will be more readily ruptured than those which are less turgid and to some extent elastic. Loss of water and hence of turgidity is inevitable to some degree during storage of fruit, and this will affect the results obtained, producing a higher figure for resistance to pressure than would otherwise have been the case. This turgidity factor is also doubtless operative in the temperature effect which has been observed by Hartman (6). He found that apples tested at higher temperatures gave a lower figure and were thus apparently softer than the same sample tested at lower temperatures. At higher temperatures the expansion of the fruit would increase the turgor of it. It is therefore important not to compare samples of fruit which are at widely different temperatures. Illustrations of some of these disturbing factors will be drawn from the results obtained herein.

Experimental.

Materials.

The samples of which the softening has been investigated are the same as those used and described in the preceding part for the catalase estimation. They comprise samples of Allington Pippin apples (i) grown under grass, and under cultivation, (ii) on which fruit thinning had been carried out and (iii) samples of Newton Wonder grown on trees which had been subjected to bark-ringing, and a control. Three picks of each series of fruits were made and placed into storage.

Apparatus.

The pressure-tester used was based on the original design published by Murneek (14), the plunger being half an inch in diameter, rounded at the tip and penetrating $\frac{3}{16}$ inch into the flesh of the apple. Modifications were introduced, however, which were so successful in facilitating rapid and accurate application of the test that a short description is appended.* (Plate 1, Fig. 1). The apparatus was designed so that a pointer was held in position by an electro-magnetic clutch operated on the closure of an electric circuit by two contacts suitably arranged on the plunger at the instant it had penetrated the required distance. The pointer of the spring balance used was removed and the axis was extended by fitting a cylindrical rod two inches long. Over this rod was mounted a smoothly fitting sleeve attached to which was a disc of soft iron $4\frac{1}{2}$ inches in diameter. Fitting over the sleeve and acting as a bearing was the drilled supporting pillar. The soft iron disc which was fitted with a pointer was thus mounted freely on, and moved independently of, the extended pointer axis of the balance. Connection between these two parts was made by a flat helical spring. It was originally intended that the movement of the balance spindle should be transmitted solely by the spring to the disc-pointer which could be locked in any position by the electro-magnetic clutch. Further movement of the balance spindle in either direction would then be taken up by the spring. The

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* The help of members of the Staff of the Physics Department of Bristol University in designing the apparatus is gratefully acknowledged.

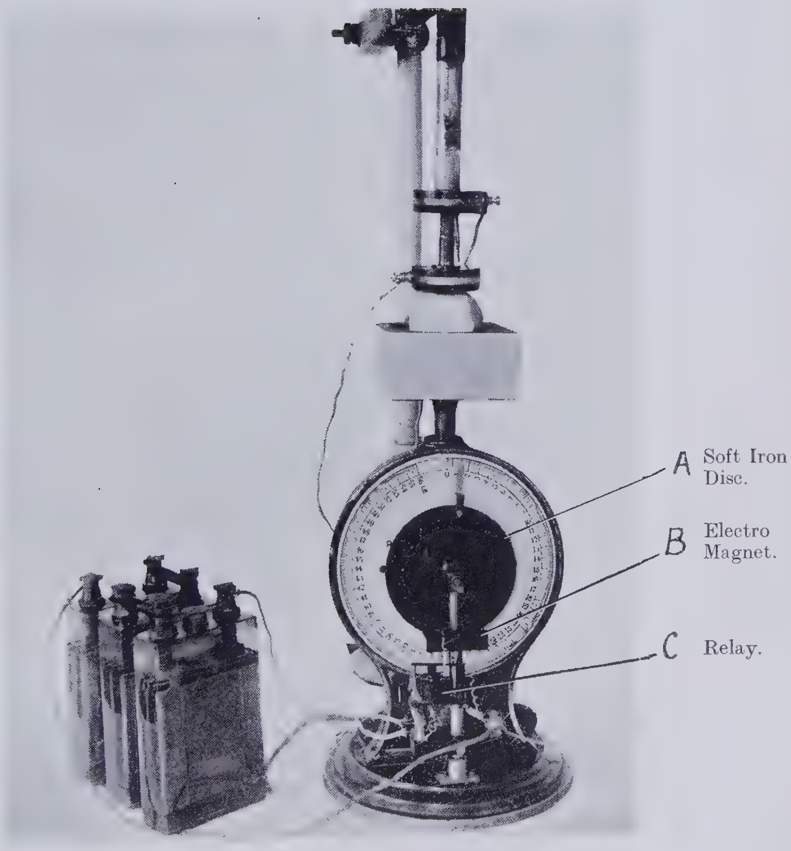
A Soft Iron Disc.
B Electro Magnet.
C Relay.

Plate I, Fig. 1.

Modified Form of Pressure Tester as used in the Present Study.

bearings, however, were too heavy to allow a smooth action when this arrangement was tried. A satisfactory modification was introduced, without re-designing the bearings, by fitting a stop on the spindle and another engaging with this on the disc. The spring was then adjusted so that the disc was pressed firmly against the stop. In this way the disc followed the movement of the spindle accurately as pressure was applied. At the moment contact was made, the disc was held firmly but the spindle was free to move beyond this point against the pressure of the spring. In this way pressure could be applied steadily beyond the actual point of contact which was marked automatically, thus making for increased accuracy and speed. On breaking the circuit, which was carried out conveniently by a foot switch, the disc was free to move back, locked against the stop with the spindle in this direction of movement. The relay C which proved to be an unnecessary refinement was included to overcome any loose or intermittent contact on the plunger.

Method.

Some care is necessary in applying the test. Pressure must be applied steadily, smoothly, and at approximately the same rate on each occasion ; if applied very slowly the reading will be low, and if applied rapidly the reading will be high. It was found that the best results were obtained when the application of the pressure occupied about ½ second and as a result of continued use this rate became standard in all the tests made. A steady application of the pressure is one of the most important points to be observed in making comparable tests, and it was from this point of view that the modified tester was found so valuable.

For the present work, samples of not less than 10 representative fruits were taken for each reading at various points during storage, the peel removed, and five tests made at points on the mid-portion of each fruit, regard being paid to reddening of the skin and distortions. The mean of the 50 or more figures thus obtained was taken as the hardness value of the sample and is the value used in plotting the curves. A complete set of figures from a typical test is given on next page in Table I.

TABLE I.

SPECIMEN READINGS ON A TEST OF ALLINGTON.

Grass. 1st Pick. 5th Sampling. March 2nd, 1933.

Reading (in lbs.).

Apple No.	1	2	3	4	5
1	8.0	9.5	10.0	8.5	8.0
2	6.0	7.5	7.0	8.0	8.0
3	7.0	6.0	5.0	6.0	7.0
4	7.5	8.0	8.5(R)	9.0(R)	9.0(R)
5	8.0	7.5	6.5	10.0(D)	10.5(D)
6	7.0	6.0	7.0	8.0(R)	7.5
7	7.5	7.5	7.0	6.5	6.5
8	7.5	7.5	7.0	6.5	7.0
9	8.0(R)	8.0(R)	6.5	6.0	5.0
10	8.5	8.0	8.0	9.0	9.0

Sum	357.5
Mean	7.5
Zero Correction	+2.5
	10.0
Standard Error of Mean ..	±1.09 lbs.

Noticeably redder portions of some of the fruits are indicated by (R), a greater hardness value being obtained at these points. The two readings in Apple No. 5 indicated by D. were of a slightly distorted portion of the fruit and were omitted in the summation for the mean.

The influence of wilting of the fruit on the hardness value obtained is illustrated by the following figures, from two fruits in which one side was relatively wilted and soft, whilst the opposite side was relatively firm and hard.

			Firm.		Soft.	
No. 1	..	7.0	6.0	6.0	8.0	7.5
No. 2	..	5.5	5.5	6.5	7.5	7.5
		Firm.			Soft.	

Again, at the third sampling of the 1st pick of the Allington Pippin, grass and cultivated series, the cultivated were much softer to the touch and were more wilted than the grass, yet the hardness value was 13.5 in the grass and 15.5 in the cultivated. Consideration is given to these disturbing factors where they arise during the discussion of the results.

The standard error of the mean is rather high, being ± 1.09 lbs. and differences of more than two pounds will therefore be required for significance on this basis. The samples as taken for the determination of the hardness value, however, are far from being random samples, but were taken in such a manner that the variation of the main sample was fully represented on each occasion. This method was followed since the labour involved in taking a random sample sufficiently large to be significant for each test was more than could be attempted. On this account the samples do not conform to a normal distribution, and it seems desirable to apply an independent test of significance. The significance of the means of representative samples have therefore been tested by Fisher's "t" method (4A). In the case of the Allington, not thinned, 3rd pick, (see Fig. 7) the first and second samplings represented by the first two points on the curve were tested in this way. " t " was found to be 55.3 for n = 98, a value which is well beyond the range of Fisher's table, and shows a very high significance of these two means. On this basis a difference of more than 0.5 lb. in the means is significant, corresponding to 95 per cent. probability, and the limit required for this probability for each series is given on the curves.

Results.

The results are presented in graph form in Figs. 2 to 10. The mean hardness value obtained as described above for each picking is plotted against the storage time in the upper curves of each figure. The experimental treatment is plotted with its appropriate control in each case and the limit of significance for each series is given on each figure. The two lower curves in each figure represent the rate of softening for the period between succeeding points in the upper curves.

The general nature of the results is in agreement with that of previous workers, a decrease in hardness taking place from one pick to the next as a result of ripening on the tree and a much more rapid decrease taking place during storage. The definite decrease in hardness value as storage proceeds is well brought out in the curves. The hardness value for the Newton series is slightly higher than that for the Allington, while the maximum decrease in value during the storage period is greater in the Allington, about 13 pounds, than in the Newton, about 11 pounds.

The obvious difficulty of adjusting the taking of samples for all the determinations which were being carried out on these lots of experimental fruits caused the determinations of hardness to be made at periods of storage which were not equal for each storage sample. This creates a difficulty which will have to be considered at a later stage of the discussion but for the present the curves will be discussed as they stand.

Discussion of Results.

As far as possible the curves will be discussed point by point, and in doing so the main interest lies in disclosing anything from which suggestions relating to the maturity of the samples can be drawn.

Examining the two upper curves of the figures in detail, it is seen that in the first pick of each series (Figs. 2, 5, 8) there is a period of from 15 to 20 days at the commencement of storage during which softening is proceeding slowly. This is shown in the rate curves by the low value of the first point. This initial period of slow softening disappears as the fruits are picked at a more mature stage so that in the second pick softening is more rapid during the initial period, and in consequence the upward kink in the rate curves tends to disappear. Comparing the grass and cultivated Allington series (Figs. 2 and 3) it is seen that the kink is smaller in the cultivated than in the grass at the first pick, and in the second it has disappeared completely from the cultivated while still present in the grass. These facts are what would be expected if the cultivated fruits were more mature than the grass. In the third pick, a second determination of hardness was not made at a sufficiently early date to include the critical point.

In the Newton series the two differently treated sets of fruits behaved very much alike at each picking with respect to this point.

The existence of a period of low rate of softening at the commencement of storage and its disappearance from samples which were more mature when picked has been reported before for apples (12), pears, and peaches (13). In these latter cases this initial slow period had disappeared completely from the last pickings which were made, as is the case in the third pickings of the Allington series.

Examining further the curves for hardness value (Figs. 2 to 7), it is seen that, once the initial slow period is passed, softening proceeds at a rapid rate and that this rate decreases as storage proceeds. The three exceptions are within the limit of significance. Thus the ideal curve for hardness value of these apples during storage is probably exponential in nature. A difference between the two varieties Allington and Newton can be seen at this point : in the Allingtons (Figs. 2 to 7) the curve is steeper during the early part of storage than in Newtons (Figs. 8 to 10). That is to say, in the Allingtons, softening takes place mainly during the earlier part of storage, whilst in the Newtons it takes place more evenly over the whole storage period, an effect which is due to the fact that, relative to their metabolism, the former have been stored for a longer time than the latter. For this reason, in the next paragraphs, figures for the early part of storage will be used for the Allingtons, and for as great a period as possible for the Newtons. The steepness of the early part of the curves is less noticeable in two cases (Figs. 2, 6), than in the remaining Allington samples. This is due to the interference from wilting which has already been discussed. These two samples wilted more severely than the others and later, in the next part of the paper, it will be seen that they lost weight at a greater rate than the others. At the third sampling of the cultivated, first pick (Fig. 2, point A), it has already been pointed out that the much wilted cultivated sample was found to have a greater hardness value than the firmer grass sample. This point is undoubtedly too high and disturbs the character of the whole curve.

In making a further study of the data, interpolated hardness values for equal intervals of storage time have been obtained from the curves for each pick. The curves have been re-drawn as straight lines using these values, but information is more readily obtained from the figures in Table II, which are expressions of the slopes of these curves. The curves for the Newton, not-ringed, series are reproduced in Fig. 10A as an example, from which it is seen that softening is more rapid with each succeeding pick, a result which is in agreement of those of other workers.

It was shown in Part IV that increase of catalase activity was also more rapid with each succeeding pick, and Fig. 10A can indeed be regarded as an inverted form of the diagram given in Part IV (page 42). The relationship of the progress of softening whilst the fruits are ripening on the tree with that during subsequent storage is thus seen to be the same as the change in catalase activity during ripening on the tree with that during subsequent storage, which is what would be expected if, as it is suggested, these factors are indices of metabolism. The figures given in Table II represent the rate of softening for a definite time, per unit of initial hardness, thus being the ratio of rate of softening per day to initial hardness, as in the case of the relative rate of catalase increase obtained in Part IV. In the Allington series the time over which the rate is calculated is 70 days, whilst in the Newton series it is 120 days.

TABLE II.

Rate of softening per day per unit of initial hardness (“ relative rate ”) in lbs. for Allington and Newton series. Values × 10^5.

	1st Pick.	2nd Pick.	3rd Pick.
Grass	630 (100)	707 (112)	728 (115)
Cultivated ..	579 (100)	622 (107)	694 (120)
Thinned	611 (100)	622 (102)	655 (107)
Not Thinned ..			752 (123)
Ringed	259 (100)	298 (115)	318 (123)
Not Ringed ..	255 (100)	316 (124)	370 (145)

The value for the not thinned. 2nd pick. will be too low on account of the serious wilting already discussed.

The relative rates are seen to increase in value from one pick to another, due to the combined effect of increase in the storage rate as seen in Fig. 10A and decrease in initial hardness. This increase in value of the relative rate is greater for the Allington, cultivated, series than for the grass, suggesting that the former are advancing more rapidly than the latter. In the same way the act of thinning and of ringing of the tree appears to have retarded the ripening of the fruits of the treated samples.

No constant effect attributable to the cold weather between the 1st and 2nd picks has been found in the treatment of the results for the softening data.

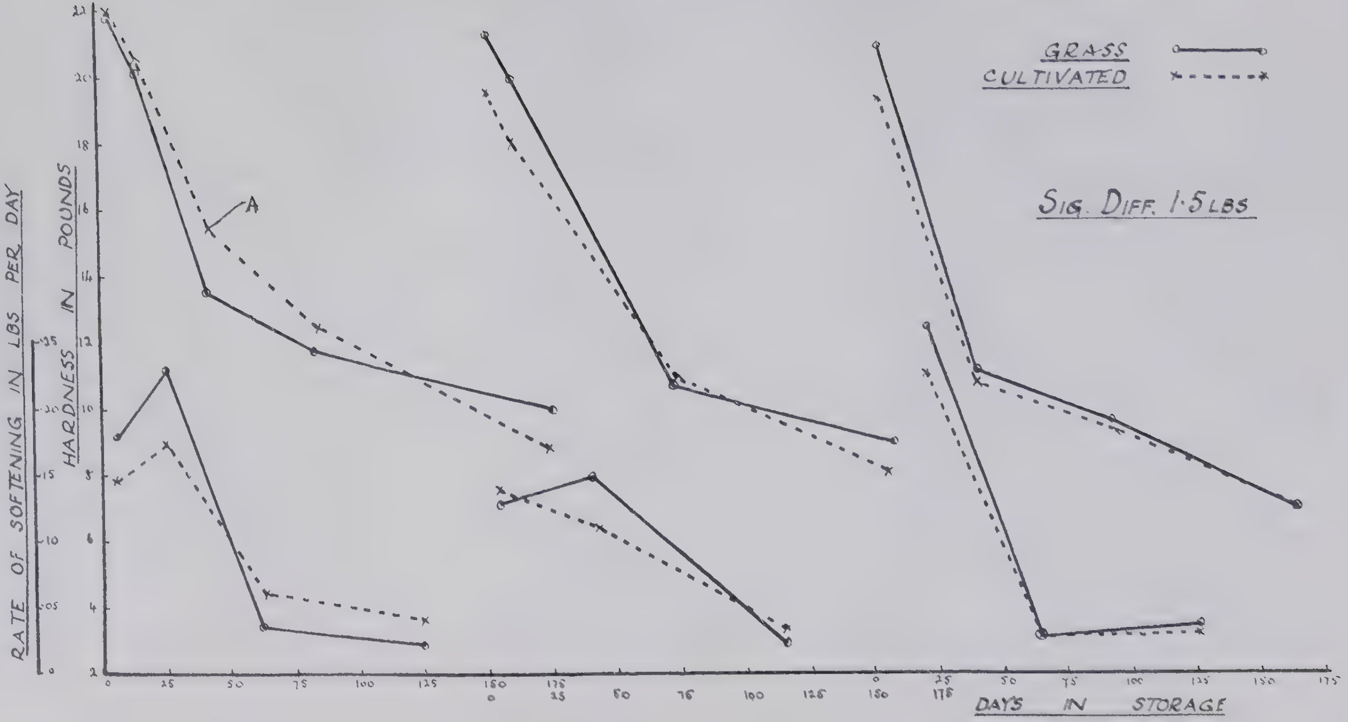

Fig. 2.
1st Pick.

Fig. 3.
2nd Pick.

Fig. 4.
3rd Pick.

Allington Pippin. Grass and Cultivated.
Progress of Softening and Rate of Softening in Storage.

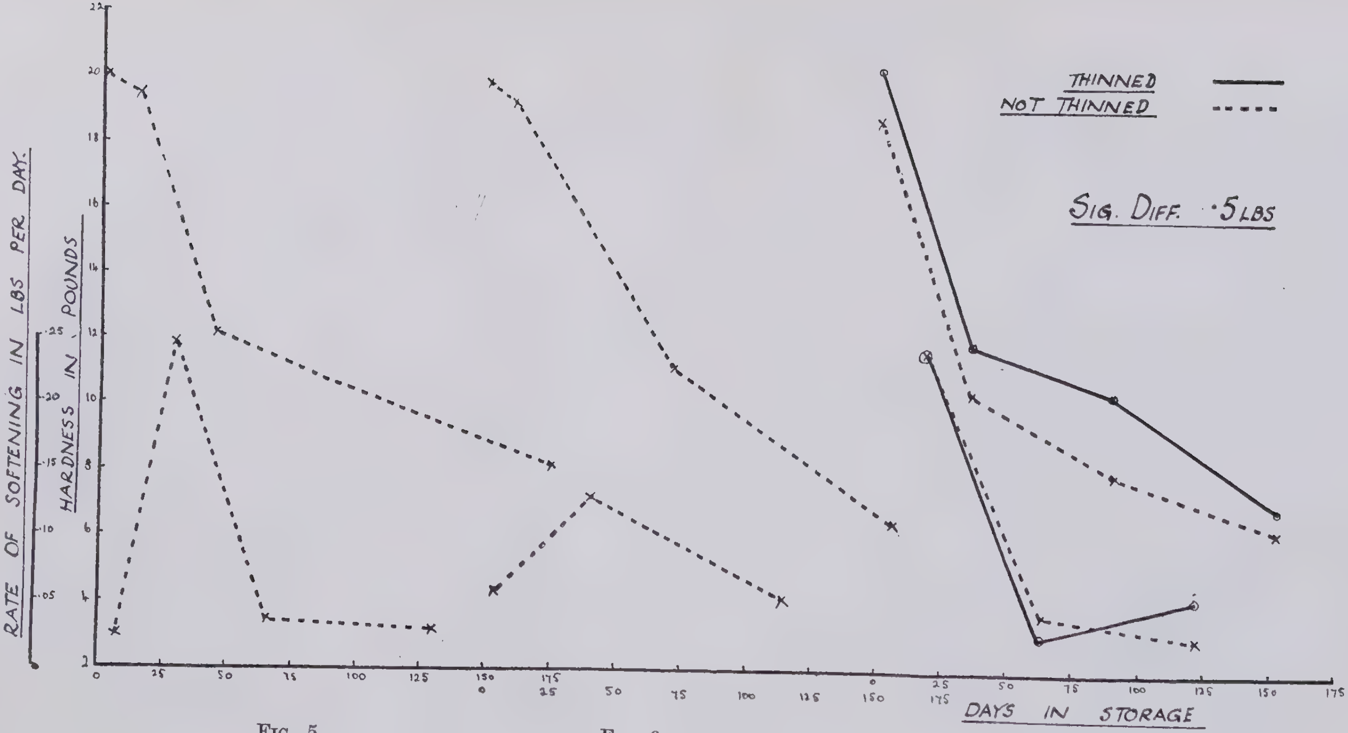

Fig. 5.
1st Pick.

Fig. 6.
2nd Pick.

Fig. 7.
3rd Pick.

Allington Pippin. Thinned and Not Thinned.
Progress of Softening and Rate of Softening in Storage.

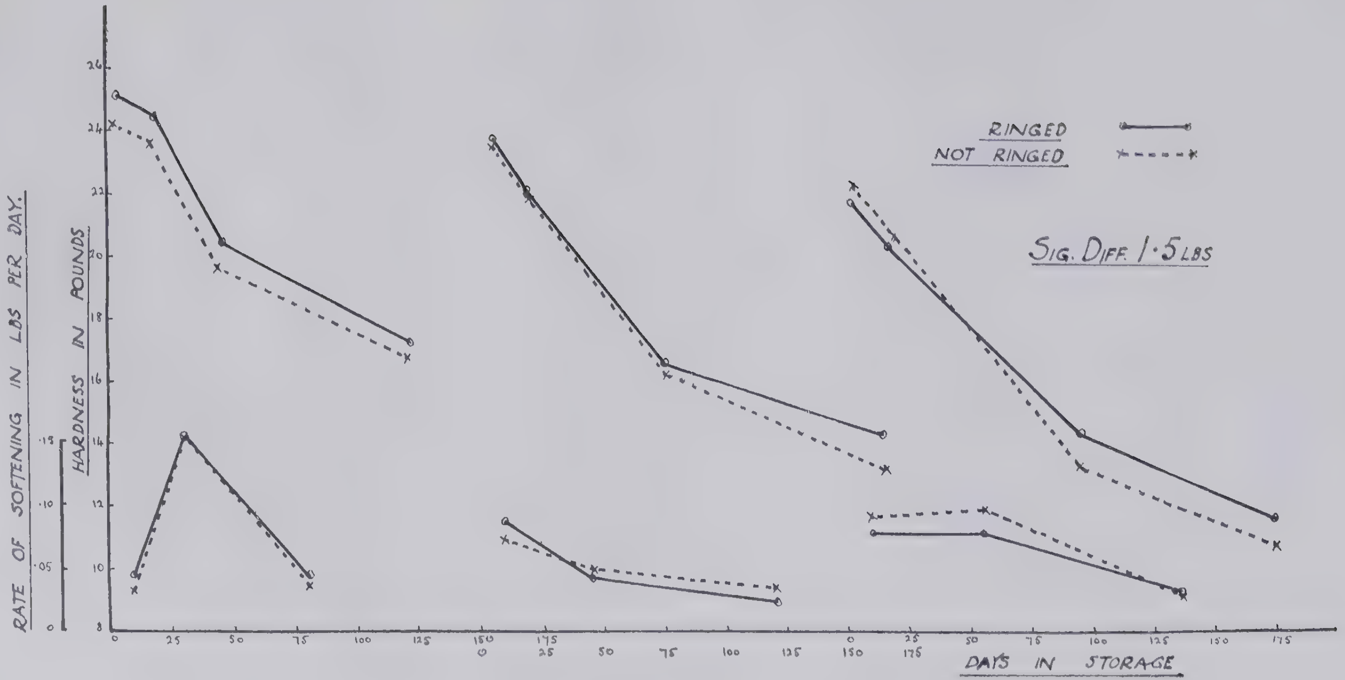

Fig. 8.
1st Pick.

Fig. 9.
2nd Pick.

Fig. 10.
3rd Pick.

Newton Wonder. Ringed and Not Ringed.
Progress of Softening and Rate of Softening in Storage.

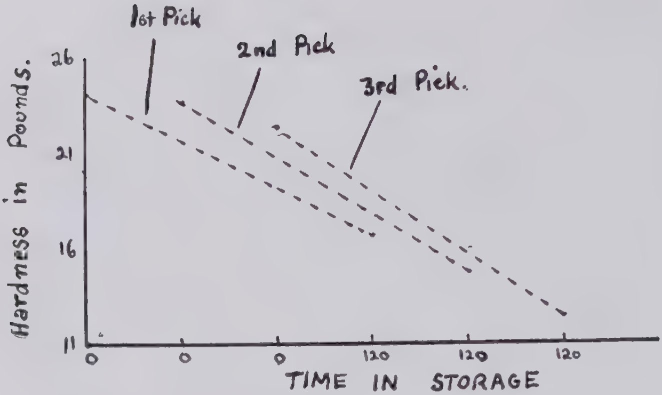

Fig. 10A.
Softening in Storage of Newton Not-Ringed for same time Interval.

B. LOSS OF TOTAL WEIGHT.

The loss of total weight during storage was followed in detail by weighing, at intervals, samples from each experiment of from 15 to 20 fruits, the number depending upon the number of fruits persisting in a sound condition until the end of the experiment. The fruits were weighed individually, and a record kept for each fruit.

The storage factors governing loss of weight from apples have been investigated in some detail by the Food Investigation Board (17). Loss of weight is due in most part to loss of water, and the chief external factors are the humidity and temperature of the air. Movement of the air over the fruit was found to have only a small effect. A decrease in the rate of loss was experienced as storage life proceeded. Certain of these results will be considered later in relation to the results of the present investigations.

Storage Conditions.

The store in the present experiments was uncontrolled both as regards humidity and temperature. Temperature fell gradually from 12°C. to 2°C. during the first half of the storage period and thereafter fluctuated between 2°C and 7°C. This amount of fluctuation is probably insufficient to affect the loss of weight to a marked degree, though the fall in the first period of storage would have a significant effect. All samples, however, were under the same storage conditions and comparisons can be made fairly.

The relative humidity varied between 80 per cent. and 90 per cent. the mean for the period being 87 per cent., as measured by Lambrect's Polymeter.

The apples were stored in trays in a single layer. Air movement was not induced artificially but the store was of large size and of such a nature that air movement would be difficult to prevent.

Significance of Results.

Since individual records were kept for each apple in the series a statistical examination of the figures is possible. In two typical samples Allington, not thinned, 1st and 2nd pick, the standard errors are ± 64.95 mgs. per day and ± 65.70 mgs. per day, the results being expressed as rates of loss. To limit significance to twice this amount will again make large differences necessary and, as in the case of the hardness figures, it is thought better to apply an independent test of significance. Comparing these two samples in which the rates of loss of weight are 275 mgs. and 324 mgs. per day respectively, $t = 2.09$ for $n = 29$. P is therefore between 0.05 and 0.02 and the difference in rates is fully significant. On this basis a difference in rate of loss of 30 mgs. per day can be considered significant. A further examination of the variance of the samples will be made during the discussion of the results.

Results.

The results of the series of weighings are presented in Figs. 11 to 19 as a series of graphs plotting rate of loss of total weight against time in storage for each sample.

The rates have been calculated in two ways :—

(1) As the loss experienced by an original 100 gms. of apple per day during succeeding periods of storage.

(2) The loss related to 100 gms. for each successive period.

The nature of the curves is the same for each method, the latter, which are reproduced, showing more pronounced effects.

Discussion of Results.

The general trend is seen to be for the rate to be at a maximum at the beginning of the storage period. It falls from this initial maximum at a speed almost (but not exactly, as will be brought out later), proportional to the value of the maximum, the higher the value the more rapid the fall in rate. The rates of the various samples fall by similar amounts, remaining in the same relative positions to one another as at the commencement. This point is not made obvious unless the curves are all plotted on the same graph.

In the majority of the cases, the rates increase markedly at the end of the storage period, and this is probably to be regarded as the general trend. The two exceptions in the Allington series are the 1st pick and 3rd pick, not thinned, the curve of the latter in addition being erratic (Figs. 14 and 16). In these two cases there has almost certainly been a selective action on the sample by wastage during the storage period. In general, it was usual for individuals having a lower rate of loss than the average to resist rots, the cause of wastage, and to be retained in the sample, thus making the average low. The extent of individual variation of this nature will be considered more fully shortly. Reduction in the number of the sample and selection from this cause was only serious in the two samples of the Allingtons mentioned. The same explanation is not applicable to the 1st and 2nd pick of the Newtons, not ringed, where a final rise in the rate of loss is also not observed, since in these cases there was no loss of fruits from the samples (Figs. 17 and 18). The cause on these occasions is not clear, but it is interesting to note that the change in catalase activity of one of these, the not ringed, 2nd pick, is unlike that of the other three samples of the 2nd and 3rd pick, which were also tested at this final stage of storage. (In the 1st pick catalase activity was not measured at this period). The rate of increase of catalase activity rises at this point in this sample, in contrast to the continued fall which holds in the others of the 2nd and 3rd picks (page 48, Fig. 12). The possibility arises that the differences with respect to catalase and loss of weight in this 2nd pick of the not ringed series might be connected with the onset of flesh breakdown to which the Newton variety is liable at about this time. No definite case of breakdown in the flesh was detected in any of the samples at this date, though breakdown at the core was commencing in all cases.

The increase in rate at the later period of storage which is seen in the majority of the cases is also roughly proportional to the initial maximum rate, which thus becomes an approximate measure of the capacity of the sample to lose weight at any stage of the storage period. This initial rate is the most important figure pertaining to each sample, and since the rates are all expressed on a per cent. basis (*i.e.* rate of loss per 100 grs. per day), it has the same nature as the relative rates which have been used in the previous section, direct comparison of the figures becoming possible. Comparing the values of this initial rate, it is seen from the graphs and the following figures that there is a rise in the value between

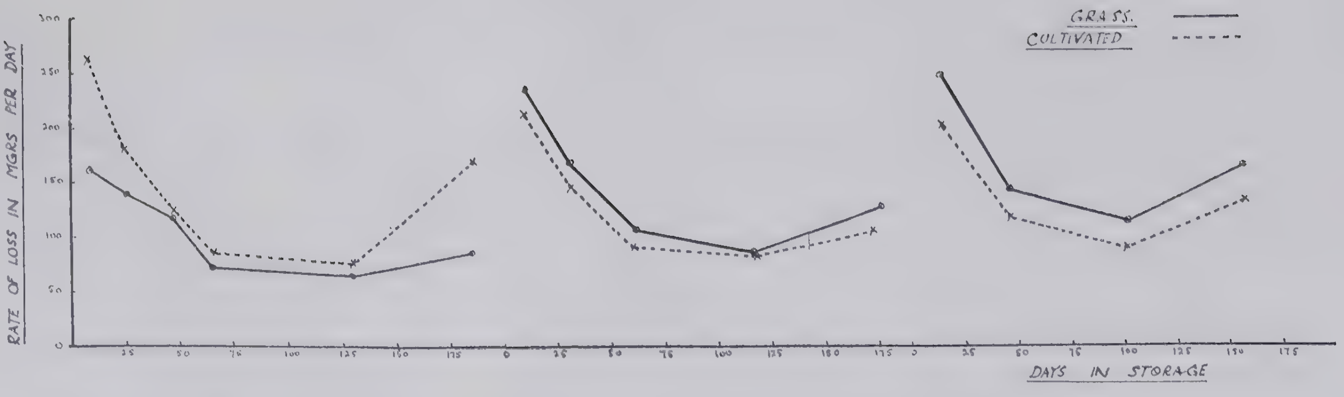

Fig. 11.
1st Pick.

Fig. 12.
2nd Pick.

Fig. 13.
3rd Pick.

Allington Pippin. Grass and Cultivated.
Rate of Loss of Total Weight in Storage.

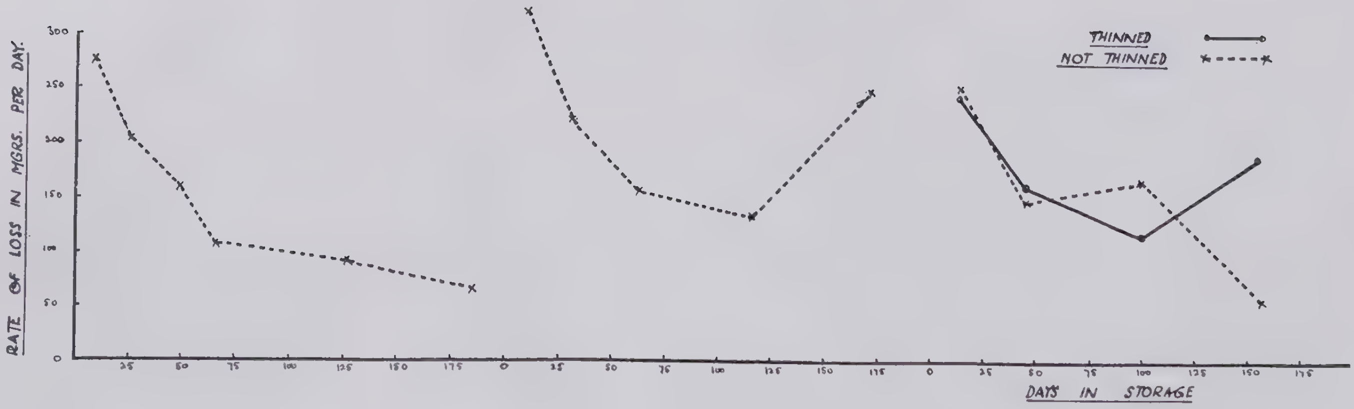

FIG 14.
1ST PICK.

FIG. 15.
2ND PICK.

FIG. 16.
3RD PICK.

ALLINGTON PIPPIN. THINNED AND NOT THINNED.
Rate of Loss of Total Weight in Storage.

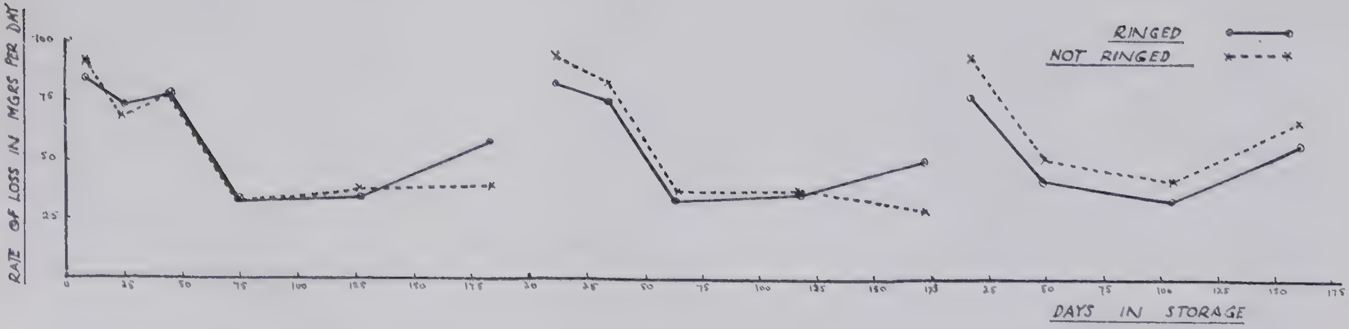

Fig. 17.
1st Pick.

Fig. 18.
2nd Pick.

Fig. 19.
3rd Pick.

Newton Wonder. Ringed and Not Ringed.
Rate of Loss of Total Weight in Storage.

each pick of the Allington, grass series, whilst there is a fall between each pick in the cultivated series.

Initial Rate of Loss in Mgrs. per day.

	1st Pick.	2nd Pick.	3rd Pick.
Grass	162	239	250
Cultivated ..	263	211	204
Not Thinned ..	275	324	254

In the Allington, not thinned, series the value rises between 1st and 2nd picks and falls between 2nd and 3rd picks. It would seem therefore that the initial rate at which this variety of apples loses weight in storage, increases to a certain maximum as the apples are picked in an increasingly ripe stage, and after this point decreases as the fruits are picked at a still riper stage. If this is true the fruits on the "cultivated" trees are at a more mature stage than those on the "grassed" trees. No inferences however can be drawn as to the effect of thinning from these results.

It is seen from the curves that the rate of loss during storage decreases in value as the storage period proceeds. This is a definite trend for all apples, as was found by Smith (17) for a constant temperature and humidity store, though in the present case the fall in temperature of the store which occurred during the early period will enhance this decrease in rate. In order to examine the decreasing rate more readily, the amount of decrease has been worked out for a standard period for all series and is given in Table III. 35 days has been made the standard period in the Allington series. Thus the rate of loss of the grass series, 1st pick, fell from 162 mgs. per day at the commencement to 120 mgs. per day after 35 days, a decrease in rate per day of 42 mgs. as shown in the table. The figures in brackets represent the decrease expressed as a per cent. of the initial rate.

From the figures in the table it can be seen that the amount of the decrease is greater with succeeding picks in the grass, and less with succeeding picks in the cultivated series, whilst in the not thinned the figure increases between 1st and 2nd, and decreases between 2nd and 3rd picks. The amount of the decrease is thus following the change in the initial rates, but it is not entirely a function of the initial rates as is seen from the per cent. figures in brackets which are not constant in value. The per cent. figures themselves change in the same way as those for the decrease, and thus suggest that this decrease in rate is a definite function of the metabolism of each sample, and has a characteristic value for each sample. At the same time, they lend further support to the suggestions as to the maturity of the samples which have already been drawn.

TABLE III.

Decrease in Rate of Loss of Weight of Apples during Storage.

	1st Pick.	2nd Pick.	3rd Pick.
Grass	42 (25.9)	99 (41.4)	105 (42.0)
Cultivated ..	130 (49.6)	92 (43.4)	86 (42.2)
Thinned	—	—	88 (35.8)
Not Thinned ..	111 (40.2)	135 (41.7)	88 (37.0)
Ringed	50 (58.9)	40 (53.4)	34 (44.2)
Not Ringed ..	50 (58.9)	41 (50.0)	35 (38.0)

The rate of loss from the Newtons is much lower than from the Allingtons and differences between succeeding picks are much smaller. Moreover, the erratic nature of the early portion of the curves of the 1st and 2nd picks is unexpected and unaccountable. For this reason it is perhaps better not to attempt to draw conclusions from those results until they are better understood. For the sake of completeness the decrease in rate of loss has been calculated as above for the straight part of each curve and is included in Table III.

A comparison of the variance of the samples has been made, and the figures are given in Table IV.

TABLE IV.

Variance of the Samples of Apples used in the Loss of Weight Determination.

	1st Pick.	2nd Pick.	3rd Pick.
Grass	.231	.470	.705
Cultivated ..	.520	.398	1.924
Thinned	—	—	1.300
Not Thinned ..	1.100	1.370	1.520
Ringed	.078	.091	.126
Not Ringed ..	.067	.120	.304

The figure for each sample has been obtained in the usual way from the deviation of each individual from the mean, and it is on the loss of weight for the first period of approximately 16 days that it has been calculated. It thus represents the variation between the behaviour of the individuals for the storage period immediately after picking.

But for the exception of the cultivated, 2nd pick, it is seen that the variance is greater the greater the maturity of the sample when picked, since both increase with succeeding picks. This is brought about by the unequal ripening of the fruits on a tree: all the fruits do not ripen uniformly but some individuals are in advance of the rest. As ripening of the crop proceeds an increasing number of individuals outstrip the average and thus the variation of a sample becomes greater as the sample becomes more mature. This in turn is reflected in the variance of the storage behaviour of the samples. Since the variance of the grass, thinned, and ringed series is increasing more slowly than that of the respective controls, it is again suggested that ripening of the former series is taking place more slowly than of the control series.

This completes the comparative examination of the series of fruits, but other matters arising out of the results obtained will now be discussed.

It is interesting to note the small variance of the Newton apples, ringed and not ringed. This is in keeping with the general impression obtained by working with this and other "late" varieties, a noticeable smoothness being found in the results.

Variation between Individuals.

The extent of the variation between individual fruits was great enough to cause a marked difference in their consistency in the case of the Allingtons, where the rate of loss of weight is high as the storage period progressed. After approximately 120 days, notes were made as to the consistency of individual fruits and in Table III a number of those which were noted as firm are compared with a number of those noted as wilted, these terms being used in a comparative sense. The rate of loss of weight of each fruit and of the average of the sample from which it was taken is given for the first three periods of storage.

The degree of variation within a sample can be seen by comparing apples No. 1, 2, 3, 9, 10 and 11, which are from the same sample, and represents the maximum variation. Though by inspection there appears to be no correlation between the weight of the apples and the rate of loss of weight, there was considerable difference in the weights of individual apples. It is hoped to analyse the figures from this point of view at a future date. From the averages of the "wilted" and "firm" fruits it is seen that there is a very marked difference in rate of loss of weight of the two sets of fruits from the commencement of storage.

There is also a further difference between these sets of fruits which is brought out by examining the decrease in rate of loss between the first two periods. This figure is included in the table and is expressed as before (values in brackets) as a percentage value

TABLE III.

Apple No.	Consistency.	Rate of loss mgm. per day per 100 gm.			Decrease ‘ d’ between periods 1 & 2, as mg. & as % of 1.	Average rate of loss of sample in mgm. per day per 100 gm.		
		Period 1	Period 2	Period 3		Period 1	Period 2	Period 3
1	Wilted	304	221	110	83 (27.3)	246	163	118
2	,,	313	211	162	102 (32.5)			
3	,,	292	190	143	102 (35.0)			
4	,,	292	219	161	73 (25.0)	254	150	168
5	,,	271	168	124	103 (38.0)	204	120	91.5
6	,,	350	236	154	114 (32.5)	239	168	107
7	,,	427	277	212	150 (35.1)	263	183	130
8	,,	295	218	158	77 (26.1)			
	Average	318	217	155	101 (31.8)			
9	Firm	233	105	75	128 (55.0)	246	163	118
10	,,	196	124	94	72 (36.8)			
11	,,	200	116	87	84 (42.0)			
12	,,	142	81	62	61 (43.0)	254	150	168
13	,,	113	67	54	46 (40.7)	204	120	95
14	,,	172	124	66	48 (28.0)	239	168	107
15	,,	200	135	100	65 (32.5)	263	183	130
16	,,	219	153	111	66 (30.2)			
	Average	184	113	81	71 (38.5)			

of the initial rate of loss. The average decrease is 101 mgm. for the wilted fruits and 71 mgm. for the firm. The higher figure for the wilted fruits is due to the general higher values for the rates ; expressed as per cent. the decreases are 31.8 and 38.5 respectively.

Thus those individuals which remained relatively firm differed from the wilted ones in two ways :—

They lost weight at a much lower rate throughout the whole storage period.

They experienced a greater relative decrease in rate of loss as storage proceeded.

In the Newton samples variation in the consistency of individuals was not noticeable, but considerable variation in rates of loss is similarly present as is shown in Table IV, in which the rates of loss for the first two periods of storage, the decrease in this rate, and per cent. decrease is given for a complete sample :—

TABLE IV.

NEWTON WONDER. RINGED 3RD PICK.

Apple No.	Rate of loss in mg. per 100 gr. per day.		Decrease 'd' between periods 1 & 2 as mg. and as % of 1.
	Period 1.	Period 2.	
1	70.0	40.5	29.5 (42.2)
2	94.5	51.3	43.2 (45.7)
3	77.2	44.9	32.3 (41.9)
4	76.0	43.3	32.7 (43.0)
5	100.0	64.0	36.0 (36.0)
6	68.9	38.7	29.2 (42.4)
7	79.0	43.0	36.0 (45.6)
8	68.8	33.5	35.3 (51.4)
9	76.5	44.0	32.5 (42.5)
10	88.5	42.5	46.0 (52.0)
11	81.6	36.4	45.2 (55.5)
12	79.3	44.5	34.8 (43.9)
13	92.0	46.2	45.8 (49.8)
14	104.0	47.8	56.2 (54.0)
15	97.8	54.8	43.0 (44.0)

These differences between individuals are very interesting and are worthy of further investigation. As they are of the same nature as the differences between samples of fruits picked at different stages of maturity, it is possible that they are due to the individuals having been picked at different stages of maturity. The maturity of a sample as a whole would thus be determined largely by the proportions of mature and less mature fruits of which it is composed. At the same time these considerations and figures bring out very well the profound influence which the stage in maturity at which the fruit is picked has upon its subsequent behaviour.

Factors Controlling Loss of Weight.

In Smith's experiments (17), the storage factors controlling loss of weight of apples were altered and investigated. In the present series of experiments on the other hand, the storage factors were comparable, and differences in the rates of loss were due to differences in the apples themselves. As the substance lost is largely water, the relative water content of the apples is a possible factor in the loss of weight. In Table V the per cent. water content and rates of loss of total weight for three points in the storage period for the experiments dealt with are compared.

TABLE V.

Comparison of the Water Content with the Rate of Loss of Total Weight of Allington Pippin and Newton Wonder Apples as used in the Experiments.

	First Pick.			Second Pick.			Third Pick.		
	Date.	Water Content %	Rate of Loss of Weight.	Date.	Water Content %	Rate of Loss of Weight.	Date.	Water Content %	Rate of Loss of Weight.
Grass	Sept. 26	87.07	162A	Oct. 14	87.66	239	Nov. 5	87.66	250
	Dec. 14	87.74	71	Dec. 14	87.33	107	Feb. 23	86.62	116
	Apr. 3	87.78	83B	Apr. 3	87.13	125	Apr. 3	85.91	167C
Cultivated	Sept. 26	87.57	263	Oct. 14	86.88	211	Nov. 5	86.71	204
	Dec. 14	87.94	86D	Dec. 14	87.79	91.5	Feb. 23	87.64	91
	Apr. 3	88.99	168E	Apr. 3	87.06	107	Apr. 3	87.40	135
Thinned							Nov. 5	86.78	246
							Feb. 23	85.82	118F
							Apr. 3	84.98	187G
Not Thinned	Sept. 26	87.49	275	Oct. 13	87.42	342I	Nov. 5	88.32	238
	Dec. 14	88.17H	108	Dec. 14	85.69	157	Feb. 23	88.18	168
	Apr. 3	88.58	66	Apr. 3	85.44	250	Apr. 3	87.73	57
Ringed	Sept. 27	88.80	84.7	Oct. 14	88.3	83.4	Nov. 5	88.04	79.2
	Feb. 22	89.60	35.2	Feb. 22	90.40	35.2	Feb. 23	89.80	34.3
Not Ringed	Sept. 27	88.40	92.4	Oct. 14	88.40	94.5	Nov. 5	87.30	96.0
	Feb. 21	89.50	38.0	Feb. 22	90.20	38.0	Feb. 23	89.1	43.0

Since the rate of loss of weight varies throughout the storage period, it is essential to compare only the determinations made on the same dates. It is not necessary to study the whole of the figures; compare the following entries:—A and I; B, C, E, and G; D, F, and H. From these figures it would seem that there is very little relation between the rate of loss of weight and the relative water content of the fruits. Furthermore, although the water content of the Newton samples is a little higher than that of the Allington samples, the rate of loss of weight is considerably lower. It is interesting to note, with respect to the Newtons that the water content increases during storage in each sample, though at the same time the loss of weight is much decreased. It seems from these considerations that there must be very little relation between loss of weight and water content.

The rate of loss of water, rate of loss of solids, and the per cent. of the loss of total weight which is represented by water, are set out in Table VI for the first storage period of the Newton series.

These figures have been calculated from the dry weight determinations, which were carried out by drying samples in a hot air oven at 70°C. for 7 days. In both ringed and not ringed series the trend between succeeding picks is for less water and more solid matter to be lost, whether the water is considered as an absolute amount or as a proportion of the total loss. It is also interesting to note that the solids are lost more rapidly from the not ringed than from the ringed series at each pick, the absolute rate of loss of water, however, being approximately the same for the two samples on each occasion. Other interesting points emerge from the complete set of data of this type, but it is perhaps better not to discuss these at the present time since the method of dry weight determination leaves much to be desired, and must be considered adequate to indicate only the broad outlines of events.

Thus it appears that loss of total weight, loss of water and loss of solids are factors which have different values for different samples of fruits, and which must be regarded as functions of each sample controlled by some internal factor. Smith, investigating the problem of water loss with reference to storage conditions also comes to the conclusion that there is some unknown internal factor involved. The effect of temperature on the rate of loss of weight of Bramleys Seedling could not wholly be explained by its effect on the vapour pressure of water. He suggested that the factor may be concerned with the path of diffusion of the water vapour inside the apple.

From the data given in Table VI, it appears that the internal

TABEL VI.

	First Pick.			Second Pick.			Third Pick.		
	Rate of loss of solids mg. per day.	Rate of loss of water mg. per day.	Loss of water as % total loss.	Rate of loss of solids mg. per day.	Rate of loss of water mg. per day.	Loss of water as % total loss.	Rate of loss of solids mg. per day.	Rate of loss of water mg. per day.	Loss of water as % total loss.
Ringed	10.5	68.5	84.9	16.3	56.5	77.6	18.3	48.4	72.2
Not Ringed	23.0	65.0	74.0	25.0	59.0	70.7	38.9	44.0	53.0

factor involved in samples used in the present case is affected by the stage at which the fruit is picked, in the same way that the other factors, catalase activity and progress of softening are affected. There is thus a possibility that the factor in this case may be a biological one, a suggestion which is further strengthened by the difference in water loss from the Allington Pippin series as compared with the Newtons. The figures for the Allington series are not sufficiently useful to be given in detail, for reasons already advanced, but the average value of the rate of loss of water is 150 mgs. per day compared with an average of 55 mgs. per day for the Newtons ; and for the rate of loss of solids is 42 mgs. per day for the Allingtons and 20 mgs. for the Newtons. Remembering that the Allington variety appears to be distinguished from the Newton by having a more intense rate of metabolism, the nature of the difference in rate of water loss between the two again suggests that the biological factor may be concerned in this loss. It is not clear how such a factor may operate, but possibly it may affect the osmotic concentration of the liquid phases present within the apple. The possibility arises, however, that it might also be the factor with which Smith is dealing. His results show that the loss of water from Bramleys Seedling apples *per unit of relative dryness* of the air, and also the temperature coefficient of this factor are not the same at all humidities, thus proving the presence of an internal factor. At relative humidities of 80 per cent. and 90 per cent. the temperature coefficient is greater than that of the vapour pressure of water, which means that at these high humidities the effect of temperature on the unknown internal factor is to cause it to assist, as it were, the remaining factors concerned in the evaporation of water. This fact is in keeping with any suggestion which would identify the factor as a biological one. The effect of temperature is not so marked at lower relative humidities, where evaporation is proceeding more rapidly and where the other known factors are probably the principal ones concerned.

It is also interesting in this connection to note the results of Tiller's experiments with Sturmer Pippin in which the relative humidity of the store markedly affected the development of breakdown in the fruits (18). Again this raises the suggestion of a close inter-relationship between humidity, water loss and the metabolism of the fruit.

In comparing the water loss from the Newton and Allington varieties, it is seen that the relative amount of total weight lost represented by water is higher in the Allingtons, averaging about 85 per cent. as against 75 per cent. in the Newtons. No data are available which might account for this, but it is thought that this difference may be connected with the heavy deposit of wax which develops on Newton during storage, and hardly at all on Allington. The relative amount of water lost from the Newtons also decreases in each succeeding pick and the development of the deposit was noticeably more pronounced in the later picks. This contrasts markedly with Allington, where no deposit was formed and no regular decrease in relative water loss with succeeding picks was observed.

SUMMARY AND CONCLUSIONS.

A. Progress of Softening.

Modifications of the original laboratory pressure-tester have been introduced whereby the pointer becomes self-locking.

The progress of softening during storage of samples of Allington Pippin and Newton Wonder apples which had been grown under certain experimental treatments and picked upon three different dates was followed.

The general results of previous workers on the softening of apples in storage have been confirmed.

From the nature of the specific results obtained the suggestion is advanced that apples which were growing on trees :

(1) growing under grass,
(2) Which had been bark-ringed,
(3) upon which fruit-thinning had been carried out,

were, in all cases, ripening less rapidly during the later period on the tree than were the respective controls, which were growing under clean cultivation and had not received the special experimental treatments.

B. Loss of Total Weight.

The loss of total weight during storage from apples from trees treated as above and picked on three different dates was followed in detail.

The rate of loss of weight was found to be different for each sample of apples obtained.

The rate of loss diminished as storage proceeded, over the greater part of the storage period, and at the final stage of storage increased again in the majority of the samples.

The extent by which the rate of loss diminished was found to have a distinct value for each sample, and the behaviour of the sample was only approximately defined by the initial rate of loss of weight.

The variance, with respect to loss of weight, increased as the samples were picked at later dates.

The rate of loss of weight, the extent to which this rate diminished in storage, and the variance of the samples were all found to be related to the stage at which the samples had been picked.

From the nature of this relationship it is suggested that the fruit from the "grass," "ringed," and "thinned" trees were ripening more slowly during the later stages of growth on the trees than their respective controls.

A study of the variation between individual fruits suggests that the variation is due to a different metabolic state of the individuals. For this reason and from other data discussed it is suggested that a main factor governing loss of total weight is biological in nature, and that loss of weight is a function of the metabolism.

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STUDIES ON MATURITY OF FRUIT.

VI.—THE EFFECT OF CONDITIONS DURING GROWTH ON SOME CHEMICAL CONSTITUENTS OF APPLES IN STORAGE.

By J. C. HINTON.

The broad outlines of the course of change of the main constituents of developing and stored apples are now known in some detail. The nature of these changes was briefly discussed in Part I of this series of studies (8). The main facts will be restated in this paper as the results of the present work are considered.

Analytical Methods.

Samples of apple material were obtained at the same time and from the same bulk that was prepared for the catalase estimations, and represent a mixed sample from 20 apples on each occasion from the various pickings and treatments described in Part IV. These are three picks from each treatment of trees of Allington Pippin which had been

(1) grown under grass cover,
(2) grown under clean cultivation,
(3) subjected to fruit thinning,
(4) not subjected to fruit thinning,

and of trees of Newton Wonder which had been

(5) bark ringed,
(6) not bark ringed.

Samples were taken from each set of fruits at intervals during storage.

Nitrogen. 30 gms. of each sample was dried in an oven at 70°C. and total nitrogen estimated on it by the Kjeldahl method.

Sugars. 50 gms. was preserved in 80 per cent. alcohol, the whole boiled for 3 minutes and sugar subsequently estimated thereon. Extraction for 18 hours with 80 per cent. boiling alcohol was carried out in a Soxhlet extractor, the extract cleared with normal lead acetate and potassium oxalate in the usual way, and the reducing substances determined by Lane and Eynon's method of using Fehling's solution. Sucrose in the cleared extract was hydrolysed by boiling with 10 per cent. citric acid for 15 minutes, and after neutralisation with NaOH reducing substances again determined.

Acid Hydrolysable. The residue remaining after extraction with alcohol was hydrolysed by boiling for 2½ hours with 2½ per cent. H_2SO_4 according to the method of the Official Agricultural Chemists of America.

The solution was neutralised with NaOH and reducing substances estimated by Lane and Eynon's method, in most cases without the need of further clearing.

Expression of Results.

The loss of weight from the fruits which occurs during storage masks to a considerable extent changes in the constituents if these are expressed as a proportionate amount of the fresh or dry weight of the sample. Therefore the curves of the loss of total weight have been used to calculate each constituent as a proportion of the original weight, this being the only way of obtaining a true picture of the change in the constituent. Thus the figures contained in this paper for each constituent are expressed as a per cent. of the original fresh weight of the sample.

A. NITROGEN.

Considerably less attention has been paid to the nitrogen content of apples during storage than to many of their other constituents. During growth it is known that the main part of the nitrogen content is established in the earliest stages of development. Thereafter the concentration of nitrogen falls rapidly for some days during the period of rapid increase in size. Subsequently, however, the absolute amount increases so that the concentration remains nearly constant, or falls slightly during the remainder of the growing period (2). Otto (15) examined the nitrogen content during storage but reported no significant change. Pilling and Pearsall (16) in a study of the various nitrogen fractions in stored apples obtained figures showing an increase in concentration of total nitrogen during storage. Their figures, however, were expressed on the fresh weight of each sample which changes during storage. Archbold (2) estimated the total nitrogen in stored apples and expressed the figures on the original weight of the samples. In this case a decrease in the amount of total nitrogen was obtained. These latter results are comparable with those of the present investigation which are also expressed on the original weight.

Results and Discussion.

The total nitrogen content at the commencement of storage in each series is given in Table I.

TABLE I.

Total Nitrogen Content at the Commencement of Storage Expressed in mgms. per 100 grs. Fresh Weight.

	Cultivated.	Grass.	Not Thinned.	Thinned.	Not Ringed.	Ringed.
Pick 1 ..	51.0	27.0	37.6	—	38.8	43.4
Pick 2 ..	47.6	24.2	38.2	—	42.2	39.6
Pick 3 ..	44.0	33.0	40.1	34.6	34.6	36.3

The nitrogen content decreases during storage and the rates of decrease for the various samples are set out in Table II. Since the content of nitrogen varied in the different samples, the rate is also expressed per unit of the concentration at the beginning of each period.

In all series but one, the Allington, not thinned, second pick, the rate of loss is highest in the earlier part of storage, and decreases markedly in the later part, as is the case with rate of increase of catalase, rate of loss of weight, and rate of loss of other constituents. In the Allington series, the early rate of loss of nitrogen is greater with the latest picked fruits, except in the case of the third pick of the cultivated series. From the data relating to progress of softening and loss of weight, discussed in the preceding paper, the suggestion was drawn that the cultivated series of the Allingtons was at a more advanced stage of maturity than the other of the Allington samples, so that the third pick of this series would be more mature than any of the other samples. If this is so the low rate of loss of nitrogen found in this third pick as compared with the second pick would represent the progress of maturity. That is to say, as apples are picked at an increasing stage of maturity, the rate of loss of nitrogen in storage increases up to a point, after which rate of loss again decreases. A similar condition appeared to hold in the case of the loss of total weight. Further confirmation of this point is required.

TABLE II.

The Rate of Loss of Total Nitrogen During Storage and the Storage Period for which the Rate is Calculated.

Column A. Rate of Loss. Column B. Rate of Loss per Unit Initial Concentration.

Rates Given in mgms. per 100 grs. Original Fresh Weight per Day.

	Cultivated.						*Grass.*					
	1st Pick.		2nd Pick.		3rd Pick.		1st Pick.		2nd Pick.		3rd Pick.	
	A	B	A	B	A	B	A	B	A	B	A	B
Rate of loss	.0844	.00165	.156	.00328	.0755	.0017	.049	.00176	.091	.00377	.192	.0058
Storage period	Days 19	to 102.	Days 4	to 59.	Days 7	to 56.	Days 19	to 94.	Days 4	to 60.	Days 6	to 55.
Rate of loss	—	—	.0337	.00086	.015	.00037	.017	.00071	.0194	.00091	—	—
Storage period	—	—	Days 59	to 145.	Days 56	to 150.	Days 94	to 183.	Days 60	to 144.	—	—
			Not Thinned.						*Thinned.*			
Rate of loss	.0417	.001	.0725	.0019	.237	.0059	—	—	—	—	.112	.0032
Storage period	Days 20	to 116.	Days 4	to 62.	Days 4	to 49.	—	—	—	—	Days 5	to 46.
Rate of loss	.0028	.00074	.0853	.0025	.054	.0017	—	—	—	—	.021	.0007
Storage period	Days 116	to 184.	Days 62	to 150.	Days 49	to 148.	—	—	—	—	Days 46	to 147.
			Not Ringed.						*Ringed.*			
Rate of loss	—	—	.062	.0014	.0217	.0006	—	—	.0426	.0010	.0254	.0007
Storage period	—	—	Days 4	to 138.	Days 6	to 121.	—	—	Days 2	to 136.	Days 6	to 120.

Comparing the rates of loss in the grass and cultivated series at the same pick, the actual rates (column A, Table II) are higher in the latter except at the third pick. This is due to the higher concentration of nitrogen however; when the rates are expressed per unit of the initial concentration, (column B, Table II), they are closely alike except at the third pick. In the thinned sample the rate of loss is less than that of the not thinned picked at the same time, which may mean that the thinned sample was either less or more mature than the not thinned at the time of picking.

In the Newton series, rates of loss of nitrogen are only available for the second and third picks, and the rate for the third pick is less in each case than that for the second. It would seem that this variety was picked at a later stage of maturity relative to its nitrogen metabolism than was Allington, where the rate of loss was increasing in most cases with succeeding picks. The fall in rate between the two picks is 57 per cent. in the not ringed series and 35 per cent, in the ringed, which may be interpreted as meaning that the not ringed series are changing, *i.e.* maturing more rapidly during ripening on the tree than are the ringed. This upholds the similar suggestion obtained from the rates of change of catalase and rates of softening.

B. ACID HYDROLYSABLE MATERIAL.

This represents the reducing substances formed by boiling all the insoluble material of the apple tissue with 2½ per cent. H_2SO_4 for 2½ hours. Chemically, it is a very indefinite fraction, including any starch which is present and, in addition, some unidentified substances probably associated with the cell wall. It has been reported by Magness (11) and Gerhardt (7) that the acid hydrolysable fraction, referred to on some occasions as hemicelluloses, undergoes a considerable decrease during the later period of ripening on the tree and also during storage of both apples and pears. Widdowson (17) has recently investigated the alcohol insoluble fraction of apples in greater detail. In her investigations the acid treatment was carried out with much more dilute acid, $\frac{N}{75}$ HCl as compared with 2½ per cent. H_2SO_4, which is approximately $\frac{N}{2}$, and under those conditions starch, pectin, and a third fraction called hemicelluloses by Widdowson were extracted and separately determined. Widdowson's results showed that little or no change in pectin and hemicelluloses took place either during the later period of ripening on the tree or during storage at 1°C. of Bramley's Seedling and Worcester Pearmain apples.

Results and Discussion.

The content of the acid hydrolysable fraction expressed as invert sugar per cent. of the original fresh weight of the various series during storage, is presented in graphical form in Figs. 1 to 9. The value falls very rapidly during the first days of storage, this being due to the disappearance of starch at this time. A slight fall during the middle period of storage is also seen definitely in the Newton series (Figs. 7, 8, 9), and is probably also present in the Allington series. Also an increase in the value of this fraction towards the end of storage is definitely seen in the Newtons and possibly may also be present in the Allingtons. An increase in the acid hydrolysable fraction towards the end of storage does not appear to have been reported before and its significance is not clear. The decrease in this fraction is to be expected, representing the hydrolysis and breaking down of the products of hydrolysis of whatever substances are included in the fraction. An increase, however, is less to be expected. It occurs at the same time that the rate of loss of total weight increases as discussed in Part V. This change in rate does not enter into the calculations, however, since they are based on the original weight of the apples. It may be that changes in the metabolism as a whole were associated with changes in the cell wall at this time as a result of which the material becomes more readily hydrolysed by acid. This point requires further elucidation.

The rapid fall in value of the acid hydrolysable fraction during the early days after picking seriously interferes with the significance of the figures obtained at the first sampling of each series since some time elapsed in each case between picking and making the first sample. As in the case of the catalase estimations, the most important time for the purposes of the present study proves to be closely following the removal of the fruits from the tree. It is in the earliest values of the acid hydrolysable fraction that any differences between the different picks of the various series stand out. Nothing definite about the effect of the treatments on this fraction can therefore be drawn from the figures obtained. The general trend is probably for the initial or tree value to decrease with subsequent pickings, representing the disappearance of the starch. The lower initial value of the grass series of the Allingtons as compared with the cultivated at each pick might therefore suggest that starch is disappearing more rapidly from the grass and that therefore this series is maturing more rapidly than the cultivated. The experiment of fruit thinning on the other hand seems to have caused a retardation of starch disappearance in the thinned series as compared with the not thinned, the thinned therefore perhaps being retarded in maturity. Into this question, however, the general level of synthesised material enters. This level appears to be greater in the cultivated than in the grass series, the amount of starch being greater as is represented by the initial figure for acid hydrolysable. This fact is not necessarily a contradiction of the general statement previously put forward that the food supply to the grass fruits may be maintained at a higher level than that to the cultivated fruits on account of the slighter competition in the grass trees due to the cessation of vegetative growth. The greater leaf area present on the cultivated trees together with their greater vigour is likely to result in more food material being available for the fruits during the greater part of their life, causing a higher level of synthesised material as starch, etc. Nevertheless, when the food supply decreases in the autumn, consequent upon the failing activity of the leaves, the competition for this supply may be less in the grass trees, as previously explained, and fruits on these trees have the supply maintained at a higher level. The act of thinning of the fruits also *increases* the general level of the food supply to those remaining, a factor distinct from *maintaining* this level. This may be responsible for the slight but distinct higher level of acid hydrolysable fraction in the thinned series throughout storage.

To overcome this complication and draw conclusions as to the relative maturity of the fruits from the variously treated trees, it would be necessary therefore to consider closely changes in the acid hydrolysable fraction whilst the fruits are ripening on the tree and also the rates of loss and relative amounts of this fraction during storage, principally during the days immediately after picking. As it has already been pointed out, this can not be done with confidence in the present case since the values obtained at the first sampling can not be regarded as sufficiently accurate for this purpose. It is interesting to note, however, that in the grass and cultivated series of the Allingtons the figures as they stand for the first sampling of the second and third picks show that though the value is much lower in the grass than in the cultivated on each of these two occasions, yet the fall in value between the two picks is 22.5 per cent. in the grass and 37.5 per cent. in the cultivated. This means that the cultivated series is probably losing its starch more rapidly than the grass series during the last few days of ripening on the tree, which would be the case if the former were ripening more rapidly. This conclusion relative to the loss of starch in grass and cultivated apples has also been reached in a more qualitative way by the use of the starch iodine test as reported in a previous paper (9). In this test the distribution and loss of starch is followed by dipping into iodine solution the surface exposed by cutting the apple in half across the middle. The starch is distributed in a very definite pattern and with experience the stage in its disappearance can be estimated in a general way. Photographs of the tests obtained in this way on the thinned and not thinned samples of this experiment are reproduced in Plate I for comparison.

C. TOTAL SUGARS.

Results and Discussion.

This is the reducing value of the alcoholic extract of the apple material after inversion by 10 per cent. citric acid for 15 minutes, obtained with Fehling's solution using Lane and Eynon's method. It is expressed as invert sugar per cent. of the original fresh weight. The results are presented in Figs. 1 to 9.

In some of the Allington series, the points are very widely distributed and the curves have been drawn between them. This illustrates well the difficulty of obtaining precise information as to general trend when dealing with the chemical constituents of fruits. The same wide distribution of points was found, though to a less degree, in the nitrogen figures and again in the sucrose figures to be discussed shortly. Equally wide variation has not been experienced in the other factors, catalase, softening, and loss of weight.

In general, the results are in agreement with those of other investigations. There is, in the days inmediately following picking, a rise in total sugars due to the hydrolysis of starch where this is present in much quantity, following which there is a fall due to respiratory loss. Archbold (4) working with apples at 1°C. found that this loss of total sugar was linear in Bramley's Seedling, and probably in Worcester Pearmain. In the present results, at a higher storage temperature, the loss of total sugar from the Newton Wonder also appears to be linear or very nearly so, but in the Allington Pippin the loss is definitely exponential in each case. In the Newton series the general level is lower in the second pick than it is in either the first or third, while the starch content as shown by the acid hydrolysable figures (Fig. 8) is much higher in the second pick than in the other two. Whether this is in any way connected with the fall in catalase activity (Part IV) between the first and second picks is not clear. In the Allington grass and cultivated series, where there was a notable depression of the catalase activity throughout the whole storage period in the case of the second pick, there is no corresponding depression in sugar the total sugar increasing progressively from first to third pick (Figs. 1, 2, 3).

Examining the Newton series more closely (Figs. 7, 8, 9), it is seen that the increase in total sugars due to starch hydrolysis in the case of the not ringed samples is smaller at each succeeding pick so that at the third pick there is no apparent increase at all. In comparison with the ringed series it would seem from this that starch hydrolysis and therefore ripeness is more advanced in the not ringed than in the ringed. It is not justifiable, however, to draw this conclusion at the present stage for a reason which can be seen more clearly by reference to the Allington series. In the first and third picks of the grass and cultivated series (Figs. 1 and 3) the rate of loss of total sugar by respiration is obviously much less in the grass series than in the cultivated. This loss in the cultivated series is also probably greater than in the grass at the commencement of storage during the period of increase due to starch hydrolysis. The change actually observed therefore is the resultant of the increase due to starch hydrolysis and loss due to respiration, and until these two factors can be separated and made clear it is not justifiable to draw conclusions from the changes observed.

The rate of loss of total sugar is also a little less in the thinned than in the not thinned at the third pick (Fig. 6). The content of total sugars in the not thinned third pick is unusually low, suggesting that the fruit on the tree used on this occasion is unusually low in sugar and that the difference between thinned and not thinned treatments with respect to sugar is exaggerated in this experiment.

No consistent results have been obtained from a detailed examination of the rates of loss of total sugars : this is probably due to an insufficient number of points being taken during the storage life to fix the curves completely.

D. SUCROSE AND REDUCING SUGARS.

The behaviour of sucrose and reducing sugars in apples during their growth and storage is known in some detail at the present time (1, 4, 5, 6, 7, 10, 12, 13, 14). During growth, within one or two weeks of fertilisation of the flower, reducing sugars and sucrose begin to increase in concentration, which increase continues until the normal picking date. Reducing sugars increase more rapidly than sucrose at first but reach a value at which the increase subsequently becomes small earlier than the sucrose. After picking, sucrose continues to increase as long as starch is being hydrolysed, and reducing sugars also continue their slow increase. Eventually in storage sucrose decreases, and at a later date the reducing sugars decrease also. In a more detailed study, Evans (6) and Archbold (4) have estimated the fructose and glucose separately. Fructose is always much higher than glucose, from two to four times, and undergoes more changes than does the glucose, which tends to maintain a steady value both during growth and subsequent storage. The behaviour of the sucrose as shown by the rate of its disappearance in store was found to vary with the date at which the apples were picked.

In the present investigation fructose and glucose were not separated. Reducing sugars are represented by the reducing power of the alcoholic extract after clearing in the usual way determined by Fehling's solution and Lane and Eynon's method, and sucrose is represented by the increase in the reducing power of the extract after hydrolysis with 10 per cent. citric acid at normal boiling point for 15 minutes.

Results and Discussion.

The results are expressed as invert sugar per cent. of the original fresh weight and are presented in Figs. 10 to 18. In general form they are in agreement with the outline summarised above, hexoses at first increasing and subsequently decreasing, and sucrose either decreasing steadily from the commencement or in some cases after an initial rise during the first few days of storage.

(*a*) *Sucrose.* Considering the curves for sucrose in more detail, it is seen that the loss is exponential in nature with the possible exception of the Allington, not thinned, second pick, and the Newton, ringed, second pick. Archbold (4) on the other hand found no uniformity in the nature of this loss; in some samples it was exponential, in others linear, and in others again in two parts each being linear but of a different value. It would seem that the increase in sucrose consequent upon starch hydrolysis must interfere with the form of the curves of loss of sucrose. In those cases where the increase is large it is shown on the curves by an increase at the commencement (cf. Fig. 10, 15): in the cases where the increase is not so large it is shown by a slower rate of loss at the commencement (cf. Fig. 11, 13). There is also an interference, from the same cause, with the calculation of the rates of loss of sucrose, especially in the earliest period when differences are mostly seen. Rates of loss have therefore been calculated for each series now being considered over the steepest portions of each curve; thus in Fig. 11 the rates have been taken from A to B and C to D. These maximum rates are presented in Table III.

In the Allington grass and cultivated series the rate of loss is lower at each succeeding pick which is in agreement with the general trend of Archbold's results (4). The same thing seems to be suggested in the other series of Allington, while in the Newtons indications suggest rather the reverse. The rate of loss per unit initial concentration shows uniformity only in the grass and cultivated Allington series, where it decreases between each pick. Moreover, it may be questioned whether comparison of rates should not be made all at the same period of storage rather than at different periods of storage as is the case here. Calculations of the rates for the same period of storage in each case, between 40 days and 90 days on the storage curve, have been made but the results in all series are inconsistent. The rate of loss of sucrose has also been related to the nitrogen content, as a possible measure of the protoplasm, but again inconsistent results have been obtained. The difficulty lies in not having a precise understanding of the inter-relationship of the starch, sucrose and reducing sugars. It is almost certain that sucrose and reducing sugars will exist in equilibrium with one another so that both starch hydrolysis and respiration will affect the whole sugar system. Without a better understanding of this relationship, it is not possible to make comparison of the relative maturity of the various series of apples.

Archbold's results suggest that hydrolysis of sucrose ceases at a time when there is still a considerable concentration remaining. This "residual" or "minimum" concentration was higher in succeeding picks. The sucrose concentration in the present work is seen to be falling so long as samples have been taken, though by the flattening out of the curves there is a suggestion that a minimum value may be reached. If this is so the curves also suggest that, in general, this value will be greater with succeeding picks. Except in the third pick of the Allington series there apparently will be no difference in this value between the treatments. At the third pick it appears that the cultivated and not thinned samples will reach a lower minimum value than the grass and thinned.

(*b*) *Reducing Sugars.* The data for the reducing sugars are given in Figs. 10 to 18. The rise in value which takes place in the first part of storage is less and the time during which the value is rising is less with succeeding picks, which is in agreement with

TABLE III.

Maximum Rate of Loss of Sucrose Experienced During Storage for Apples Grown Under Different Conditions.

Rate Expressed in mgms. per 100 grms. of Original Fresh Weight per Day.

First Pick.			Second Pick.			Third Pick.		
Rate of Loss.	Initial Conc. per cent.	Rate per unit initial Conc.	Rate of Loss.	Initial Conc. per cent.	Rate per unit initial Conc.	Rate of Loss.	Initial Conc. per cent.	Rate per unit initial Conc.
43	2.58	16.7	34	*Cultivated.* 2.74	12.4	22.6	2.97	7.6
31	2.49	12.4	20.2	*Grass.* 2.65	7.6	11.4	2.22	5.1
20	2.34	8.5	20.5	*Not Thinned.* 2.97	6.9	18.3	2.34	7.8
				Thinned. —	—	20.4	2.58	8.4
9.6	1.65	5.85	11.3	*Not Ringed.* 1.60	7.05	11.8	2.0	5.9
7.9	1.33	5.95	7.0	*Ringed.* 1.45	4.84	10.5	1.75	6.04

Archbold's results. In the third pick of the Allington series there is probably very little rise at all, the value having already nearly attained the maximum when placed in store. The rate of increase of reducing sugars was found by Archbold to increase with succeeding pickings, but in the present case the reverse is found, the rate of increase decreasing with succeeding pickings.

TABLE IV.

Rate of Gain of Reducing Sugars During Storage in mgms. per 100 grms. Original Fresh Weight per Day.

	Cultivated.	Grass.	Not Thinned.	Thinned.	Not Ringed.	Ringed.
1st Pick ..	64.0	58.0	57.0	—	27.1	20.5
2nd Pick ..	33.0	45.0	57.3	—	21.0	18.6
3rd Pick ..	15.0	2.0	4.8	3.3	10.0	9.7

The rate in each case is the highest attained by each sample, which was in most cases for the period of approximately 16 days at the commencement of storage. It must be pointed out, however, that in view of the rapidity of the increase in the reducing sugars under the storage conditions used, a greater number of points would be desirable in making calculations of the rates.

In the Newton series, the changes in reducing sugars are very smooth and the ringed series contain more than the not ringed at each pick (Figs. 16, 17, 18). The rate of increase of reducing sugars is higher in the not ringed series than in the ringed, but this difference is reduced with succeeding picks, the fall in rate from one pick to the next being slightly greater in the not ringed than in the ringed (Table IV). There are no consistent differences between the different treatments in the Allington series. The general level of reducing sugars is higher in the third pick of the thinned and the grass series than in the not thinned and cultivated.

E. RATIO $\frac{\text{REDUCING SUGARS}}{\text{SUCROSE}}$.

This ratio has been calculated as a possible indication of the relationship of the reducing sugars and sucrose. The results for the Allingtons, presented in Figs. 19 to 24, do this to the extent that though the concentration of reducing sugars at times increases

TABLE V.

$\frac{\text{Reducing Sugars}}{\text{Sucrose}}$ Ratio for Newton Wonder During Storage and for Allington Pippin at the Commencement of Storage.

First Pick.			Second Pick.			Third Pick.		
Days in Store.	Ratio $\frac{R.S.}{S.}$	Basis 100.	Days in Store.	Ratio $\frac{R.S.}{S.}$	Basis 100.	Days in Store.	Ratio $\frac{R.S.}{S.}$	Basis 100.
				Newton.	*Ringed.*			
9	5.03	100	3	4.26	100	6	4.12	100
45	9.4	187	55	7.1	167	42	5.45	132
88	10.7	213	137	11.6	272	120	11.9	289
151	13.7	272	198	44.5	1045	167	10.9	265
				Newton.	*Not Ringed.*			
10	3.78	100	4	3.69	100	6	3.45	100
44	7.53	199	54	10.4	282	41	5.75	167
87	8.15	216	138	11.3	306	121	9.35	271
153	11.3	299	197	13.1	355	168	12.4	360
				Allington.	*Grass.*			
10	2.49	—	4	2.30	—	6	3.40	—
				Allington.	*Cultivated.*			
5	2.24	—	4	2.07	—	7	2.32	—
				Allington.	*Thinned.*			
—	—	—	—	—	—	5	2.77	—
				Allington.	*Not Thinned.*			
11	2.54	—	3	1.87	—	4	2.77	—

and at times decreases, and the rate of loss of sucrose changes considerably during storage, yet the ratio increases in value at approximately a steady rate. In order to facilitate comparison of the change in the ratio during storage the graphs are based on an initial value of 100 in each case. The actual initial values are given in Table V. This actual value of the second pick is lower than the first in all of the Allington series, and the third pick is higher than the first in all cases. In the Newton series, on the other hand (Table V), the actual initial value falls between each succeeding pick.

The rise in value of the ratio during storage is less in the later picked sets of Allington with the exception of the not thinned, second pick, where the rise is about the same as in the first pick. There is a marked difference between the grass and cultivated and between the thinned and not thinned series at the third pick, the rise in value during storage being much less in the grass and thinned series than in the cultivated and not thinned. There is possibly a similar difference in the second pick but little if any in the first. Grass treatment and thinning, therefore, cause greater change between picks than do the other respective treatments and from this point of view would suggest that the two former sets of fruits are maturing more rapidly than the controls. This suggestion has to be put against those previously drawn which are in the opposite sense.

In the Newton series, though the changes of reducing sugar and sucrose are very smooth, the change in value of $\frac{\text{reducing sugar}}{\text{sucrose}}$ is very irregular. Curves are not given, therefore, for this series but the figures are included in Table V. Neither in a difference between the three picks nor between the two treatments can any uniformity be seen or conclusions drawn.

SUMMARY AND CONCLUSIONS.

A. Nitrogen. Total nitrogen of apples of Allington Pippin and Newton Wonder decreased during storage.

The rate of decrease was greatest during the early part of storage and was influenced by the stage of maturity at which the fruit was picked.

The rate of decrease was, in general, greater in the Allington fruits picked at a later stage, but was less in the Newton fruits picked at a later stage.

The nature of the relation of rate of decrease with the stage of maturity at which the fruits are picked is in agreement with the suggestion that the "grass," "thinned," and "ringed" fruits were not ripening as rapidly as their respective controls.

B. Acid Hydrolysable Material. The acid hydrolysable fraction decreased markedly during storage but in many cases underwent an increase, towards the end of storage life.

Definite conclusions relative to the maturity of the samples cannot be drawn from the results obtained. Those for the grass and cultivated samples, however, suggest that the latter may have been ripening on the trees more rapidly between the second and third picks of the series.

C. Total Sugars. The results of previous workers have been confirmed, but no further conclusions can be drawn from the data obtained.

D. Sucrose and Reducing Sugars. The curve for loss of sucrose during storage was found to be exponential in nature in the majority of the samples.

The rate of loss as calculated for the steepest portion of each curve decreased between succeeding picks in the Allington series, but tended to increase between picks in the Newton series.

There was evidence that the loss of sucrose would cease at a time when a residual amount was still present. This residual amount increased with succeeding picks. These facts are in agreement with previous work.

The amount of increase of reducing sugars in storage, and the length of time during which increase in value took place, was less with succeeding pickings in each case, which is in agreement with results of other workers.

The rate of increase in reducing sugars in storage was found to decrease with succeeding pickings in all cases. This is contrary to results of previous workers.

E. Ratio Reducing Sugars/Sucrose. The ratio increased during storage in all cases.

The increase in value of the ratio was less in the later picked fruits of the Allington series, and from the nature of the results the fruits from the grass and the thinned trees may be considered to be ripening on the trees more rapidly than their controls, which is contrary to conclusions suggested from other data.

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PLATE I.

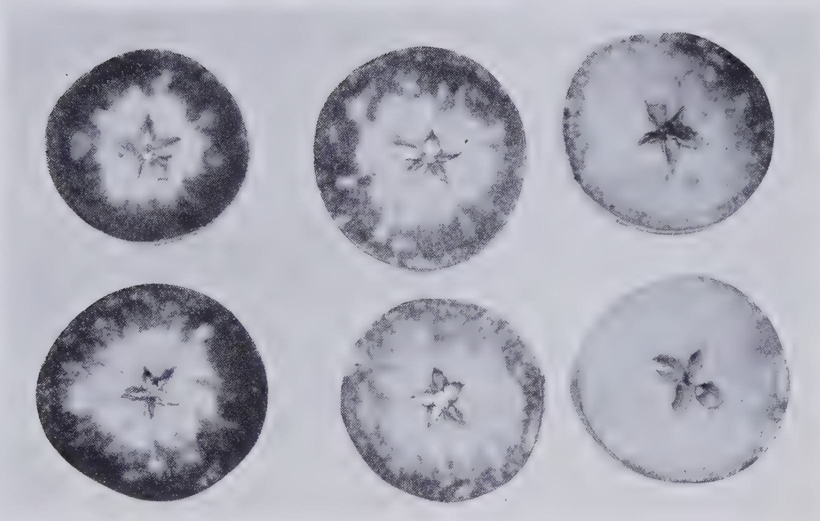

FIG. 1.

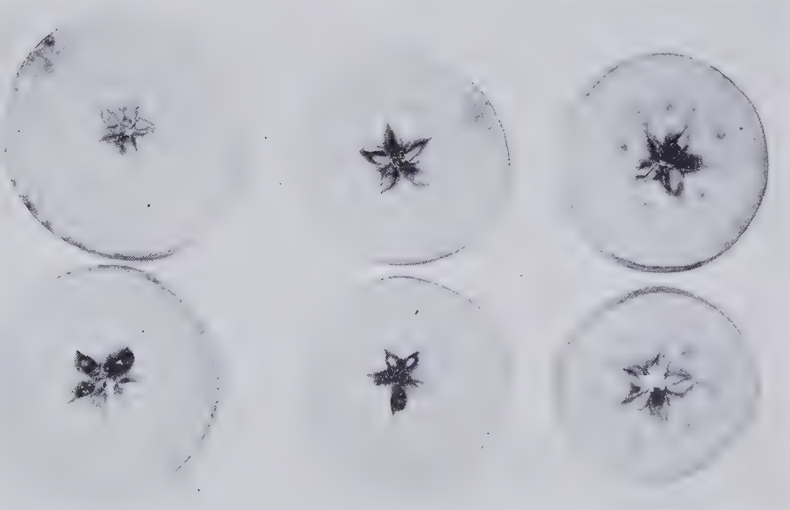

FIG. 2.

STARCH PRINTS OF ALLINGTON PIPPIN.

FIG. 1. THINNED.

FIG. 2. NOT THINNED.

Note Heavy Deposits of Starch in Thinned as compared with Not Thinned Fruits.

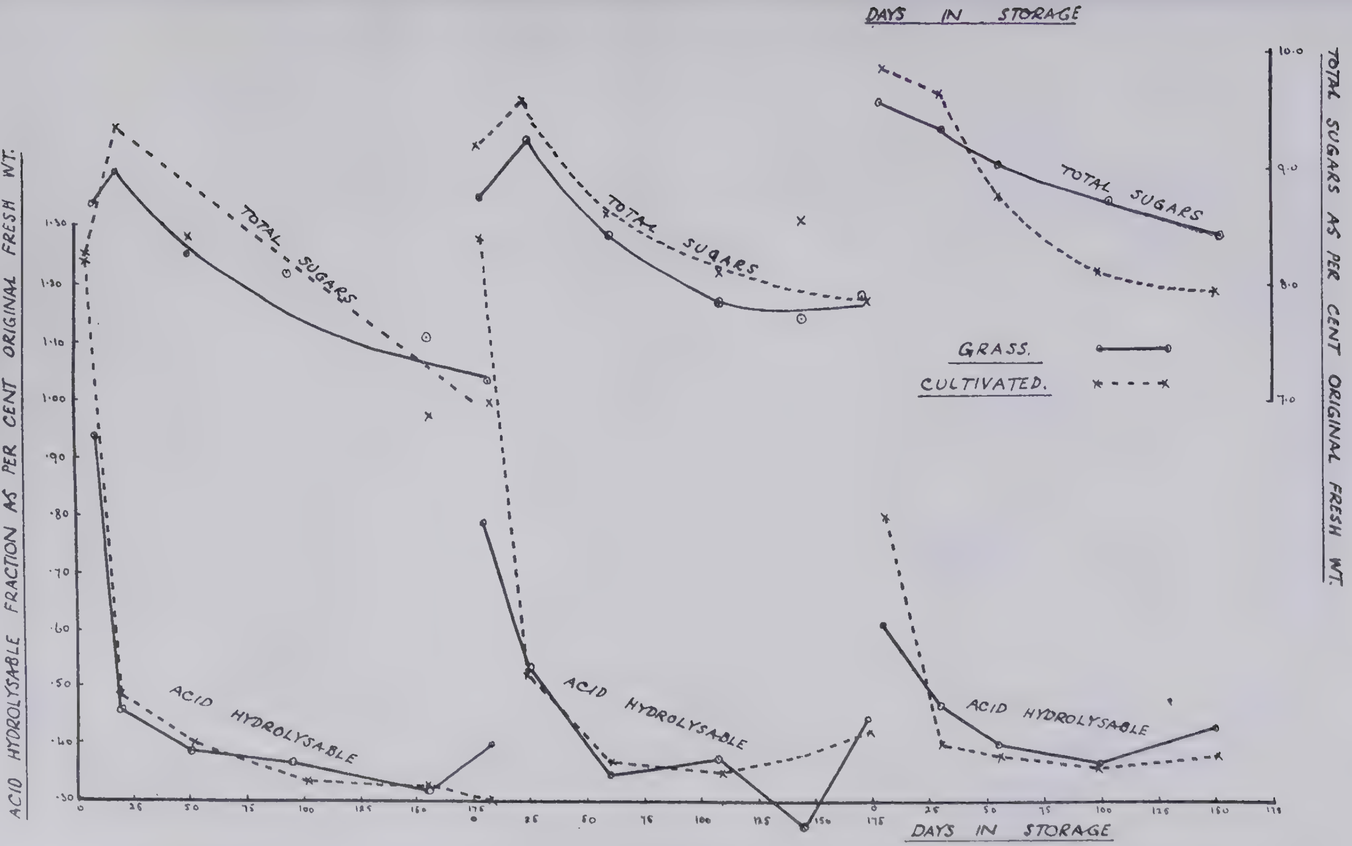

Fig. 1.
1st Pick.

Fig. 2.
2nd Pick.

Fig. 3.
3rd Pick.

Allington Pippin. Grass and Cultivated.
Change in Acid Hydrolysable Fraction and Total Sugars during Storage.

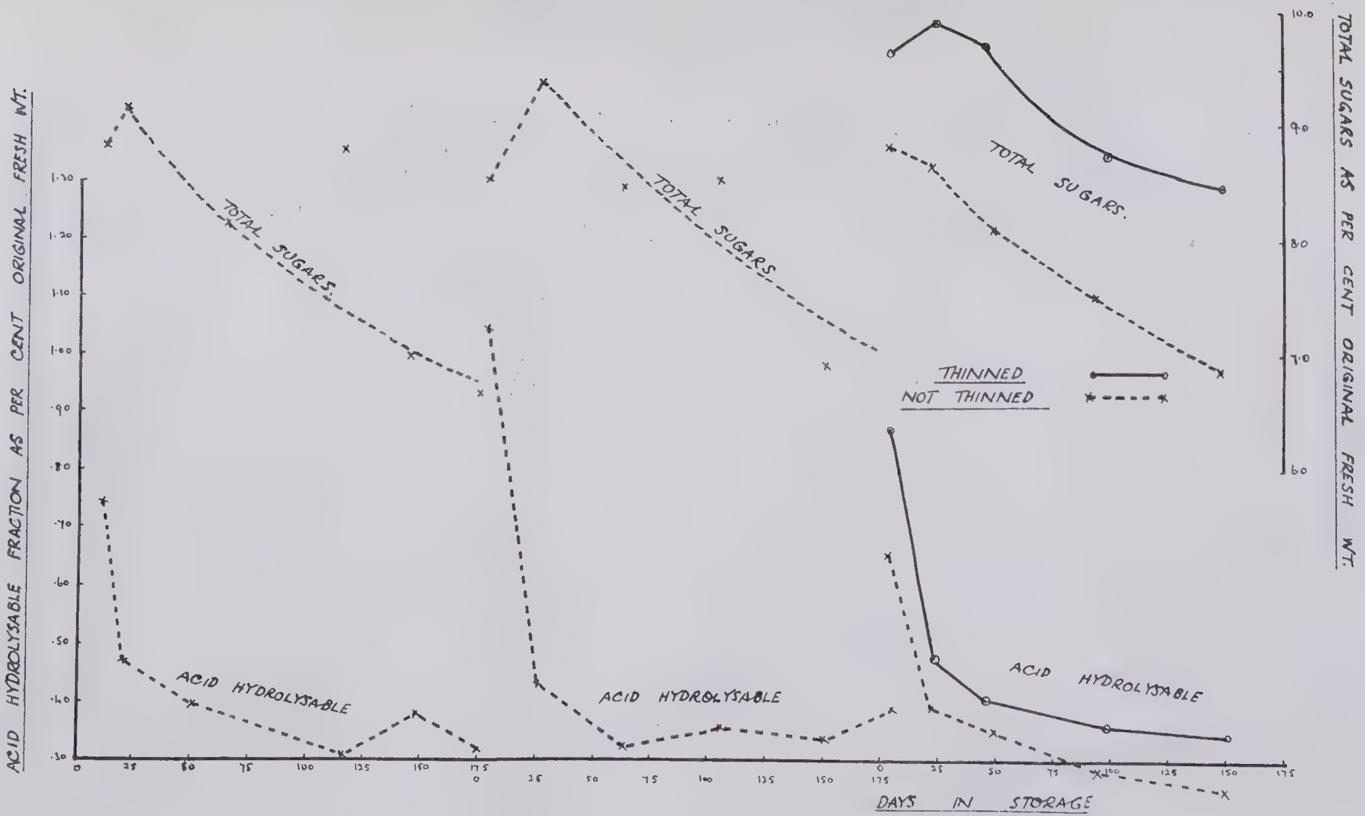

Fig. 4.
1st Pick.

Fig. 5.
2nd Pick.

Fig. 6.
3rd Pick.

Allington Pippin. Thinned and Not Thinned.
Change in Acid Hydrolysable Fraction and Total Sugars during Storage.

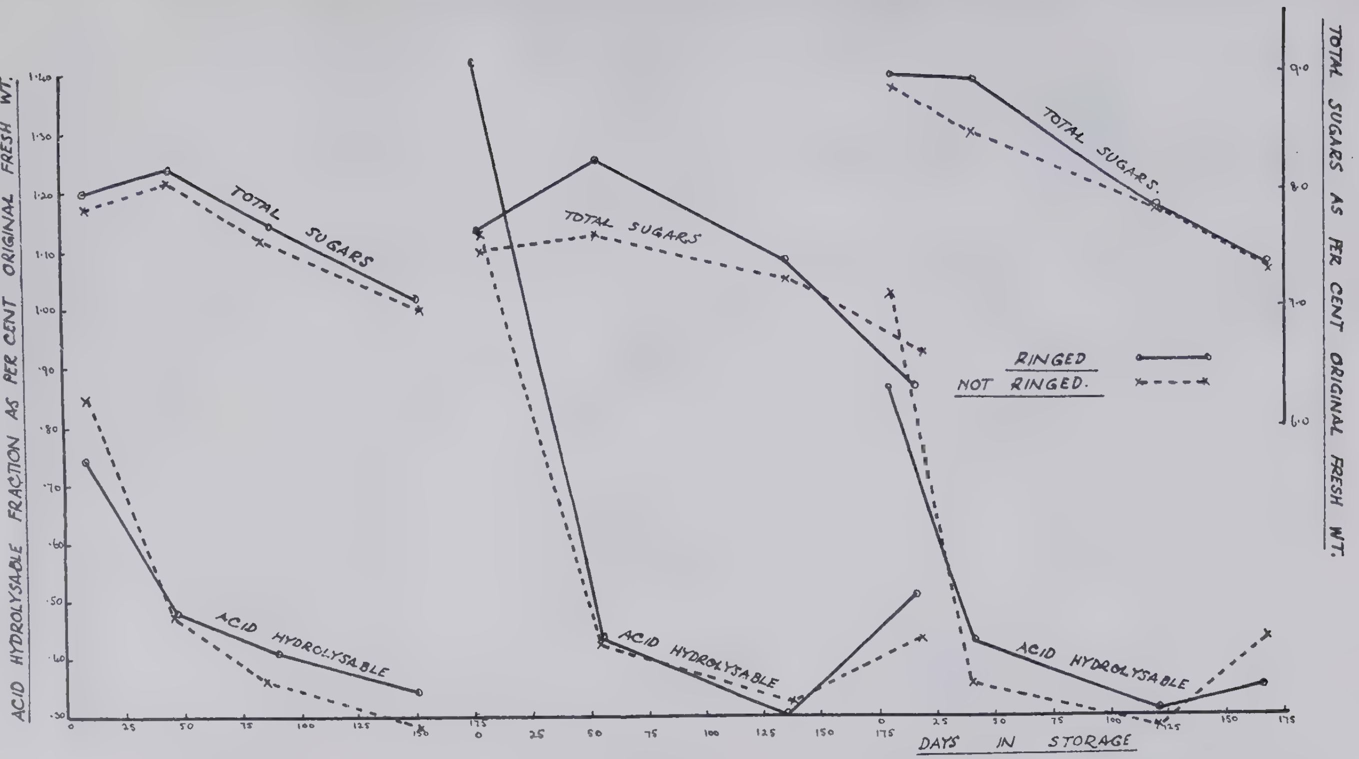

Fig. 7.
1st Pick.

Fig. 8.
2nd Pick.

Fig. 9.
3rd Pick.

Newton Wonder. Ringed and Not Ringed.
Change in Acid Hydrolysable Fraction and Total Sugars during Storage.

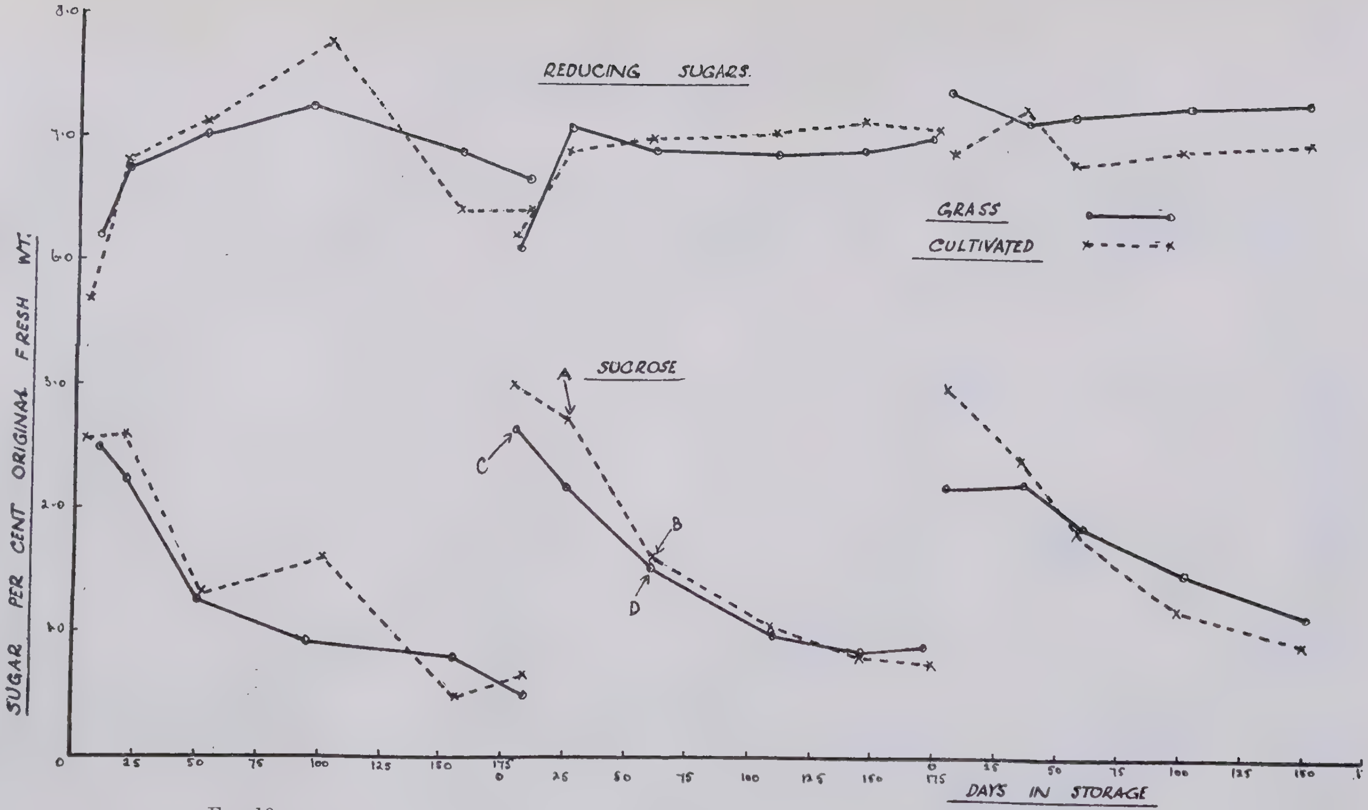

Fig. 10.
1st Pick.

Fig. 11.
2nd Pick.

Fig. 12.
3rd Pick.

Allington Pippin. Grass and Cultivated.
Change of Sucrose and Reducing Sugars during Storage.

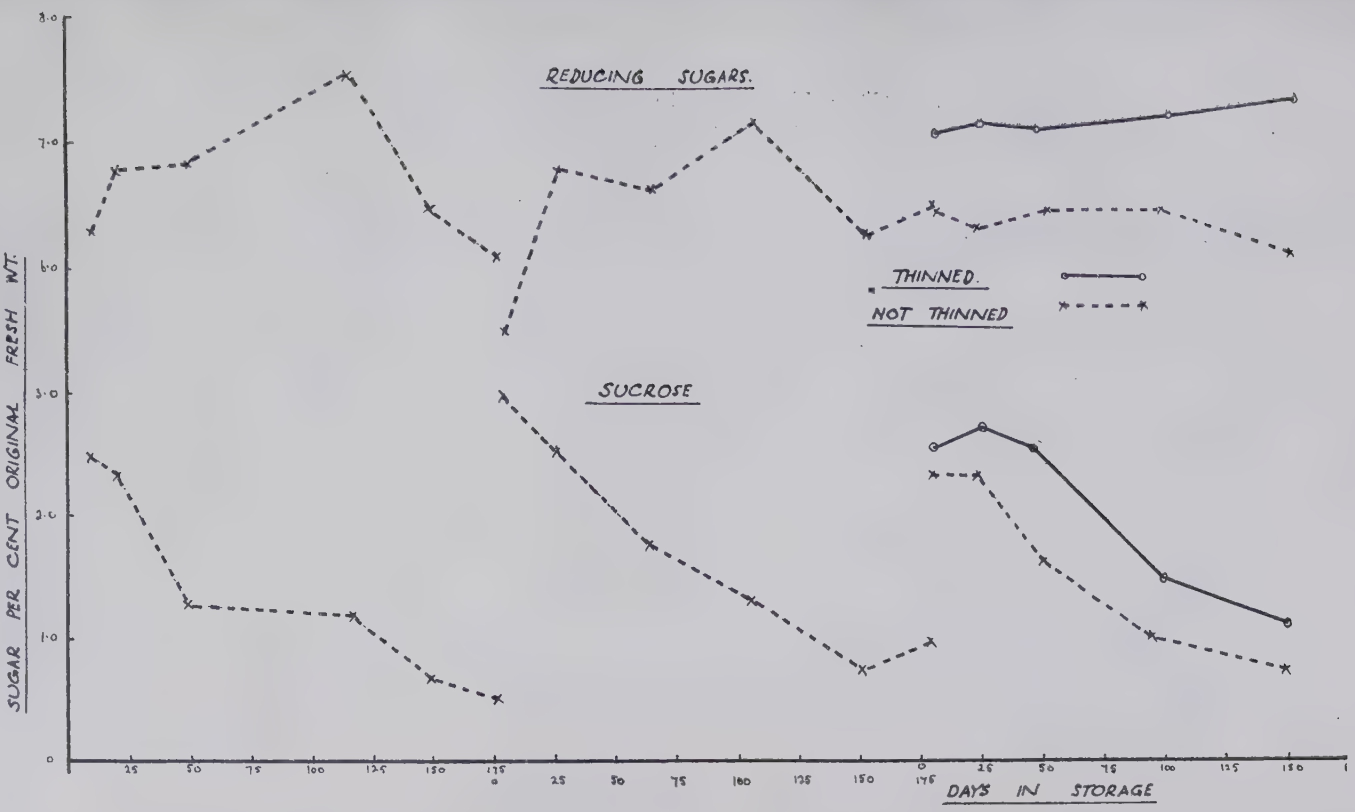

FIG. 13.
1ST PICK.

FIG. 14.
2ND PICK.

FIG. 15.
3RD PICK.

ALLINGTON PIPPIN. THINNED AND NOT THINNED.
Change of Sucrose and Reducing Sugars during Storage.

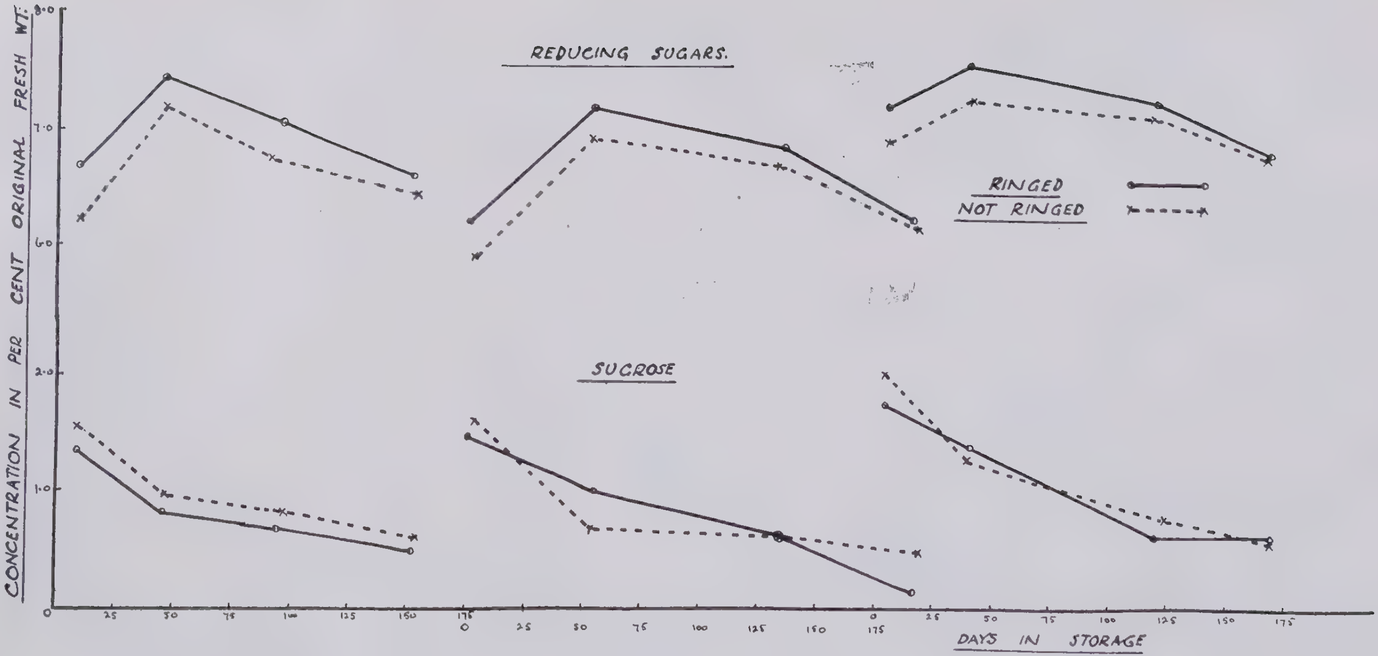

Fig. 16.
1st Pick.

Fig. 17.
2nd Pick.

Fig. 18.
3rd Pick.

Newton Wonder. Ringed and Not Ringed.
Change of Sucrose and Reducing Sugars during Storage.

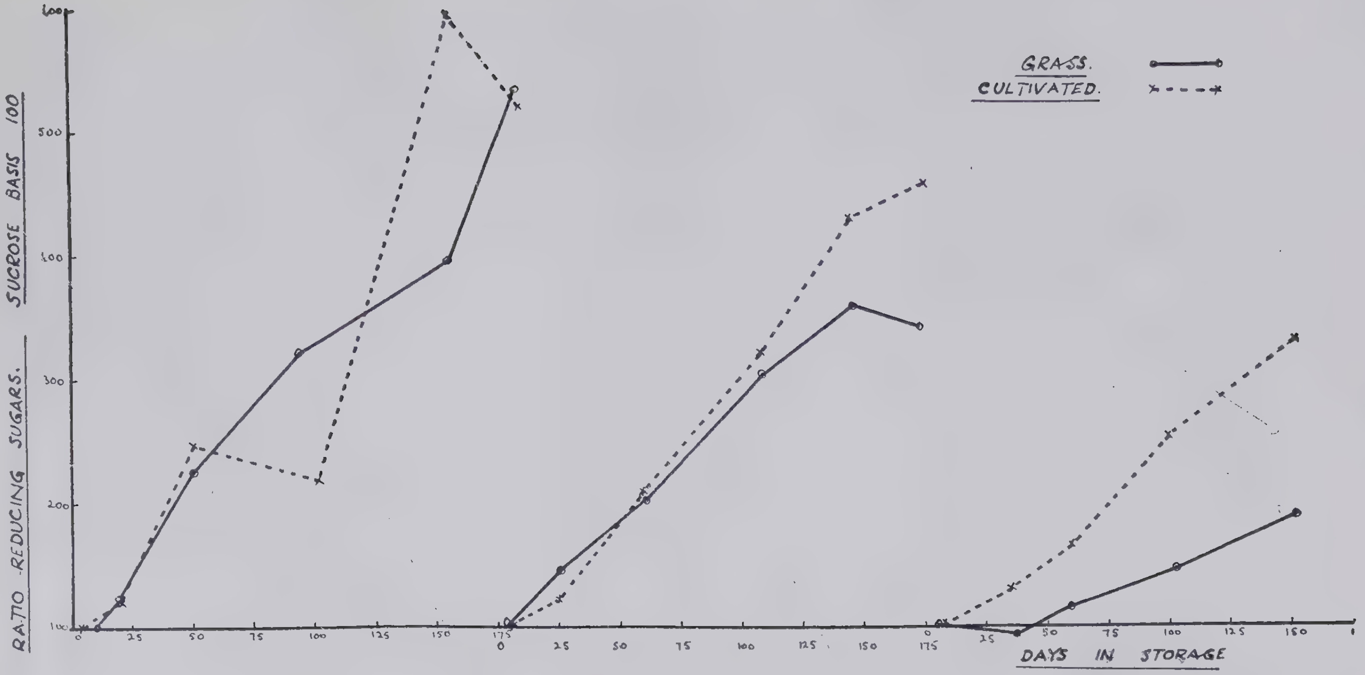

Fig. 19.
1st Pick.

Fig. 20.
2nd Pick.

Fig. 21.
3rd Pick.

Allington Pippin. Grass and Cultivated.
Change in Ratio $\frac{\text{Reducing Sugars}}{\text{Sucrose}}$ during Storage.

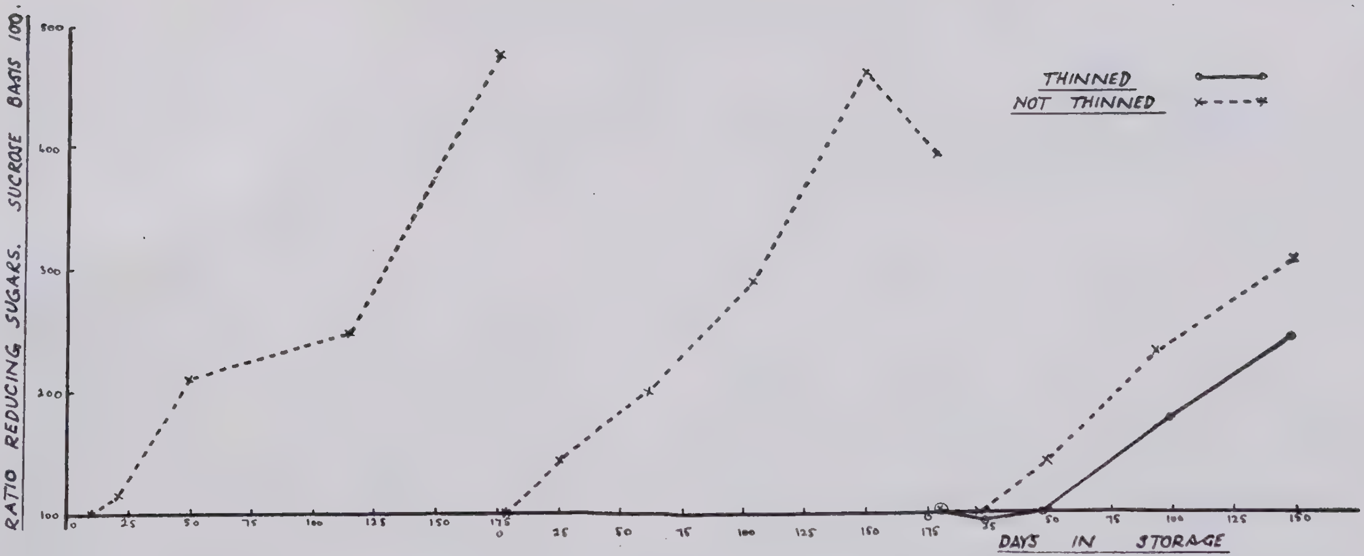

FIG. 22.
1ST PICK.

FIG. 23.
2ND PICK.

FIG. 24.
3RD PICK.

ALLINGTON PIPPIN. THINNED AND NOT THINNED.
Change in Ratio $\frac{\text{Reducing Sugars}}{\text{Sucrose}}$ during Storage.

COMBINED WASHES.

PROGRESS REPORT.

By **H. G. H. KEARNS, R. W. MARSH, and H. MARTIN.**

I. INTRODUCTION.

The need for the combination, in one wash, of two or more toxic materials, normally applied separately, arises from the overcrowded spraying programme now required for the production of clean and profitable crops of fruit. The derivation of a satisfactory combined wash involves insecticidal, fungicidal and phytocidal problems, for it must not be inferior in practice to the separate insecticidal and fungicidal sprays it is intended to replace. Successful field trials repeated for several seasons must be the basis of general recommendations. For this reason it must not be assumed that the mention of a specific combination in the present report is an indication that it is recommended for use by growers. The purpose of this paper is solely to report progress on certain lines of work carried out during the past season.

II. COMBINED WASHES ON APPLES.

Previous work upon combined washes carried out at Long Ashton has been summarised by Kearns, Marsh and Pearce (5), and that at Wye by Martin (9). The former investigators were concerned with the incorporation of contact insecticides in the lime sulphur-lead arsenate spray ; the latter dealt with the modification of Bordeaux mixture to permit the simultaneous application of contact insecticides. In both studies, the major problem was the discovery of methods whereby the protective ingredient, *i.e.* lime sulphur, lead arsenate or Bordeaux mixture, could be applied in the heavy amounts necessary for the contact wash without loss of protective ability or increase in phytocidal properties. For this purpose, two methods were found of promise, (1) the use of water-soluble spreaders which appear to function by reducing the tendency to drop formation upon the sprayed foliage, and (2) the incorporation of either glyceride or hydrocarbon oils which, in themselves of some insecticidal value, improve the retention of the protective deposit and also serve as effective carriers for other contact insecticides.

1. Water-soluble Spreaders with Protectants.

a. Materials.

Soap, the most widely used spreader, is unsuitable for use with lead arsenate, lime sulphur or Bordeaux mixture, because of its interaction to form soluble arsenic derivatives dangerous to foliage, or insoluble calcium compounds having no spreading properties. Many soap substitutes compatible with these protectants are, however, now available for experimental work. These include sulphite lye (8), a waste product from wood pulp manufacture, and the gamma-sulphonates from petroleum oil refining (10). These are both cheap products for which methods for the estimation of the active spreading constituents are still wanted to permit of their standardisation.

There are also numerous synthetic products elaborated for textile processing, and of these one or two have become available as spray spreaders in the last five years. Certain of these products, though patent-protected, are of declared and standard composition. During the 1934 season, the textile wetters used in spray trials included (i) Agral 1 and N, of which the active constituents are stated to be the alkali sulphonates of cyclic hydrocarbons containing aliphatic side chains, Agral N having approximately twice the content of active constituents of Agral 1 ; (ii) Igepon T (powder), of which the active ingredient is the condensation product of taurine and oleic acid ; (iii) Lethalate Wetting Preparation, a product compounded of the alkali salts of di-isopropyl naphthalene sulphonic acids, sulphonated lauryl alcohol and a small proportion of a natural gum ; and (iv) Sulphonated Lorol, which contains the sodium salt of the sulphuric acid ester of " Lorol." Lorol is the trade name for the fatty alcohols, mainly dodecyl alcohol, obtained by the hydrogenation of coconut fats and fatty acids.

Pending the result of more detailed work into the chemistry and spreading properties of these materials, somewhat arbitrary concentrations were used in the field trials. Experiments at Long Ashton in previous seasons (4) have shown that 8 oz. of Lethalate Wetting Preparation per 100 gallons of a mixed wash gives satisfactory wetting of foliage and apple fruitlets. This concentration was therefore also adopted for Agral N, Igepon T and Sulphonated Lorol in the 1934 field trials. Small scale trials on miscellaneous foliage indicated that, at these concentrations, the wetting ability of the sprays was equal or superior to that of sulphite lye at 6 pints of syrup (60°Tw.) per 100 gallons, or crude calcium gamma-sulphonates at 1½ lb. per 100 gallons.

b. Field Trials.

(i) *Kemerton.* The spreaders described above were tested at Kemerton, Glos., on a block of 12-year-old Worcester Pearmains, comprising ten buffered rows each of 24 trees. For this trial the rows were divided into 20 half-row plots as shown in Table I, which gives the arrangement of the treatments and controls.

For comparing the relative efficiency of the wetters, apple sawfly control was used as the criterion. The percentage of blossoms infested with sawfly eggs was determined on May 28th, 4 days after petal fall, and the results are included in Table I. It will be noted that the infestation increased progressively from row 6 to row 14, and that the average infestation was 24 per cent. Ordinarily, such an infestation would lead to almost complete loss of crop in unsprayed Worcesters, but in the present instance the majority of the eggs were laid in late-opening or small flowers, while the flowers which actually set fruit exhibited a relatively small proportion of the total infestations.

Experiments in the previous season (4) had shown that a high degree of control of the pest could be expected following two applications of combined washes, the first, 4-5 days before the majority of the eggs hatched and the second at or just after egg hatch. This programme was followed in the 1934 trial but the circumstances of the second spraying were abnormal in that a very rapid development of the fruitlets took place, the calyx cup being closed by the sepals, so that the ready entry of the wash was prevented. Consequently the value of the second spraying was less than in the previous year.

The date of the first spraying was May 28th, when the whole block, excluding the controls, was treated with washes which, in addition to the spreader, contained 8 oz. nicotine and 2 lb. lead arsenate powder (300 mesh) per 100 gallons. The second spraying was on June 4th, when the washes contained spreader, 8 oz. nicotine and $1\frac{1}{2}$ gallons lime sulphur per 100 gallons. To each of these washes the wetter appropriate to the half-row plot was added at the following strength.

Agral N, Sulphonated Lorol Igepon T, Lethalate Wet. Prep.	8 oz. per 100 gallons.
Sulphite lye	6 pt. syrup (60°Tw.) per 100 gallons.

Crude calcium gamma-sulphonate—$1\frac{1}{2}$ lb. per 100 gallons. Each tree received approximately $2\frac{1}{2}$ gallons of wash at each treatment, applied at 300 lb. pressure in favourable spraying conditions.

TABLE I.

LAY-OUT OF TRIAL OF WETTING PREPARATIONS.

THE FIGURES SHOW THE PERCENTAGE OF SAWFLY-INFESTED FRUITLETS FROM INDIVIDUAL TREES IN EACH BLOCK.

	Percentage of blossom infested with eggs. May 28th.															
Row 5		Sulphonated Lorol	8.6	14.1	4.8	7.3	Unsprayed	22.3	43.6	16.4	35.8	Agral N	12.2	2.7	16.1	6.6
Row 6	19.0	Sulphite Lye	9.7	13.8	4.4	3.7						Igepon T.	5.5	3.6	6.4	6.9
Row 7		Agral N	7.6	9.8	6.4	13.2						Sulphite Lye	14.3	14.9	23.6	10.5
Row 8	19.0	Lethalate Wetting Preparation	5.7	13.6	10.8	10.2						Lethalate Wetting Preparation	11.8	12.3	11.6	6.6
Row 9		Igepon T	5.7	15.4	14.8	6.7	Unsprayed	42.0	46.5	39.2	17.8	Sulphonated Lorol	17.3	10.3	20.8	6.9
Row 10	23.5	Calcium gamma-sulphonates	10.8	—	12.4	12.3	Unsprayed	31.5	35.2	38.6	—	Calcium gamma-sulphonates	8.1	39.6	25.2	24.9
Row 11		Lethalate Wetting Preparation	11.5	18.0	21.2	6.9						Igepon T	10.9	19.1	20.3	26.8
Row 12	31.0	Igepon T	12.0	10.8	9.2	5.0	Unsprayed	50.4	33.8	38.3	35.0	Agral N	21.5	16.1	32.4	19.3
Row 13		Sulphonated Lorol	15.8	10.6	12.0	19.0						Sulphonated Lorol	15.5	14.6	20.4	14.8
Row 14	24.5	Agral N	11.4	18.7	18.4	18.8	Unsprayed	46.0	49.0	25.8	31.6	Lethalate Wetting Preparation	13.5	25.5	10.8	10.6

The degree of sawfly control obtained was estimated on June 27th and 28th by four observers who counted total fruits and infested fruits on all the control trees and on four trees in each half-row plot. These counts are expressed as percentage sawfly-attacked fruitlets per tree in Table I. Examination of the figures from the control blocks shows the unevenness of the infestation. A statistical analysis of the four blocks, which include trees washed with the Agral N, Igepon T, Lethalate Wetting Preparation and Sulphonated Lorol sprays, gave the following result :—

Variance due to	*Degrees of Freedom.*	*Sum of (deviations)^2*	δ^2
Treatments	3	89.62	29.87
Blocks	3	785.27	261.76
Observers and Position ..	3	112.82	37.61
Error	54	847.78	15.70

Significant differences in sawfly control have therefore not arisen through difference in insecticidal efficiency of the various treatments.

Summarizing the average results :—

	No. of trees examined.	*Percentage sawfly-infested fruitlets.*	*Significant difference.*
Agral N	16	14.45	4.04
Igepon T	16	11.19	
Lethalate Wetting Preparation	16	12.51	
Sulphonated Lorol	16	13.30	
Sulphite lye	8	11.86	
Calcium gamma-sulphonates ..	7	19.04	
Unsprayed	19	35.73	

It may be concluded that the trial has failed to show any difference in insecticidal efficiency due to difference in the wetting ability of Agral N, Igepon T, Lethalate Wetting Preparation and Sulphonated Lorol at 8 oz. per 100 gallons. The results further suggest that these wetters at this concentration are not more effective spreaders than sulphite lye at 6 pints syrup (60°Tw.) per 100 gallons. The apparently inferior efficiency of the wash containing 1½ lb. crude calcium gamma-sulphonates may be associated with the greater sawfly infestation of that part of the block in which this spray was applied.

The relatively poor level of sawfly control obtained throughout the trial is evidently associated with the early closing of the calyx cup which rendered the second application of little value. In addition, it is possible that larvae hatching from eggs laid late in abortive blossoms between the spray applications migrated into sound fruitlets and thus helped to increase the figures of sawfly infestation.

(ii) *Long Ashton* (*Plot 7b*). A second spreader trial was carried out on part of plot 7*b* at Long Ashton, using three rows each of 12 trees of Worcester Pearmain planted in 1920. Here again the relative merits of the wetters were appraised on a basis of apple sawfly control. The observations relevant to sawfly infestation in this block were as follows :—

May 16-20 ..	Majority of eggs laid.
May 18 ..	Full petal fall.
May 29 ..	Majority of eggs hatching. Fruitlets swelling rapidly but calyx cups still open.
June 1 ..	A few larvae found.
June 2-3 ..	Majority of eggs hatched.

The infestation through the block was patchy and was greater in the upper branches, as shown by the following table :—

	Percentage of flowers infested with eggs.	
	Up to 6ft. above ground level.	*More than 6ft. above ground level.*
Row 8	9.67	24.2
Row 2	10.9	13.6

As at Kemerton the loss of crop following this infestation was considerably lighter than anticipated.

Spraying was carried out on May 22nd, using a 9 h.p. Edwinson outfit and two guns. The treatments permitting of comparison of spreaders were :—

Row 8 : Control ..	1½ gallons lime sulphur per 100 gallons.
Row 2 ..	1½ gallons lime sulphur, 8 oz. nicotine, 1 lb. Agral N per 100 gallons.
Row 4 ..	1½ gallons lime sulphur, 8 oz. nicotine, 6 pt. sulphite lye (60°Tw.) per 100 gallons.

Counts of total and of sawfly-infested fruitlets were carried out in the third week of June. The sum totals per row, ignoring end trees, were as follows :—

	Total fruitlets.	*Percentage sawfly-attacked fruitlets.*
Row 8	2971	28.30
Row 2	4502	2.99
Row 4	3363	3.09

The results show that the combined washes have effectively reduced the attack, and that there is no noteworthy difference in sawfly control between the washes containing Agral N (at 1 lb. per 100 gallons) and sulphite lye (at 6 pints syrup 60°Tw. per 100 gallons).

Owing to the dry season, scab attack was negligible and no variation in the control of this disease due to the different treatments could be demonstrated.

2. Hydrocarbon Oils with Protectants.

a. Materials.

It has been a frequent recommendation in the American literature (see *e.g.*, 1, 2) that the application to apples of a petroleum oil wash shortly before or after that of a lime sulphur wash should be avoided because of a liability to cause damage. It is therefore imperative that an adequate trial should be given to the lime sulphur-petroleum oil combination before it is recommended generally. Spray damage trials were accordingly continued at Long Ashton in 1934 in which the petroleum lime sulphur combination was tested on a wide range of varieties in comparison with the standard lime sulphur and lime sulphur-arsenate applications. To emulsify the oil, two methods were used, the first, by means of sulphite lye, a method described in a previous Annual Report (5) ; the second, by employing the gelatinous precipitate obtained when ferrous sulphate is added to lime sulphur as the emulsifer, using the spray pumps to complete the emulsification.

The ferrous sulphate method of emulsification gave a very quick-breaking emulsion and it seemed doubtful whether agitation in the spray tank was sufficient to ensure a uniform distribution of the oil. Samples were therefore taken at various stages of the spray as it left the spray guns, and subsequent analysis showed that the oil content of the samples was not uniform, being in the ratio of 0.64 in samples taken while the tank was full, 0.61 when the tank was half-empty and 0.45 when the tank was almost empty.

b. Field Trials.

(i) *Long Ashton* (*Plot* 11). Tests of spray damage were made on a plot comprising 17 rows each of 20 trees planted in 1923. Each row running from north to south is of a single variety, the commercial varieties included being Bramley, Worcester, Newton, Grenadier, Blenheim, Ross, Ellison, Bath, Lambourne, Lane, Superb, Rival, Cox and Allington. All spray treatments were carried out with a 9 h.p. Edwinson outfit supplying two guns and drenching applications were given throughout.

On April 19th, the whole plot received a " green flower " application of 3 per cent. lime sulphur. On May 2nd, at the early pink stage, trees 6 to 17 in each row were sprayed with a combined wash of 3 per cent. lime sulphur plus 3 per cent. refined petroleum oil of characteristics given in Table II, emulsified with sulphite lye. The remainder of the plot, excepting two control trees in each row, was again sprayed with 3 per cent. lime sulphur. This spraying took place in hot, sunny weather, followed two days later by heavy rain. On May 8th, conspicious marginal leaf scorching was noted on the trees of Allington and of Beauty of Bath sprayed with oil-lime sulphur. Apart from this the damage was negligible.

The arrangement of the post-blossom treatments on May 22nd was as follows :—

Tree numbers in each row.		*Treatment.*
1, 2, 13, 14	..	Lime sulphur + lead arsenate.
3, 4, 17, 18	..	Lime sulphur.
5, 6, 11, 12	..	Lime sulphur + lead arsenate + refined oil emulsified with sulphite lye.
7, 8, 15, 16	..	Lime sulphur + lead arsenate + refined oil + ferrous sulphate.
9, 10, 19, 20	..	No spray.

The materials were employed at the following amounts per 100 gallons :—

Lime sulphur	..	1 gallon.
Lead arsenate powder (300 mesh) ..	..	2 lb.
Ferrous sulphate	..	5 lb.
Refined oil ..	..	1 gallon (equivalent to $1\frac{1}{2}$ gallons of the emulsion made with sulphite lye).

No damage resulting from the post-blossom treatments was seen in any part of the plot.

(ii) *Long Ashton* (*Plot 7b*). The lime sulphur-petroleum oil combination was also applied to one row (twelve trees) of Worcester Pearmain on another portion of Plot 7*b* at Long Ashton. The quantities used per 100 gallons were: lime sulphur $1\frac{1}{2}$ gallons, nicotine 8 oz., refined oil (specified in Table II) 1 gallon, emulsified with one-half of its volume of 20 per cent. sulphite lye (60°Tw.). This spray was also applied on May 22nd, and the sprayed row gave a percentage of 2.1 sawfly-infested fruitlets in a total of 1849, a degree of control comparing favourably with the 3.09 per cent. obtained from the lime sulphur-nicotine-sulphite lye wash. No sign of spray damage or of apple scab was seen on the sprayed trees.

3. Ferrous Sulphate in Combined Washes.

(*a*) *Materials.*

In cases where there is an objectionable interaction between the components of a combined wash, it may be possible to diminish or prevent the effects of the interaction. That lime sulphur reacts with lead arsenate is well-known and this interaction has prejudiced the adoption of newly-introduced lead arsenates of fine particle size which theoretically might be superior to the older lead arsenates. With these so-called colloidal lead arsenates the advantages of a fine state of division are lost when added to lime sulphur, for the lead sulphide formed coagulates the arsenate to a heavy sludge.

As Goodwin and Martin (3) have shown that the interaction between lead arsenate and lime sulphur occurs through the formation of hydrogen sulphide from the monosulphide sulphur of the lime sulphur, it is probable that the interaction will be prevented if the monosulphide sulphur is first precipitated as an insoluble sulphide. Of the possible materials to use, ferrous sulphate seems to have several advantages: (i) its use has already been advocated by Waite (12), and latterly by Kelsall and Hockey (6), as a means of reducing injury caused by lime sulphur sprays; (ii) the oxidation of ferrous sulphide after application to foliage will result in the liberation, as free sulphur, of the monosulphide sulphur which, in lime sulphur, is dissipated as hydrogen sulphide; (iii) this *in situ* decomposition of the ferrous sulphide to ferric oxide may improve the retention of the sulphur and arsenate deposit on the foliage; (iv) the ink-like spray deposit being clearly visible on foliage may facilitate complete spraying. Finally, the possible functioning of the ferrous sulphide-sulphur precipitate as an emulsifier has been described above.

To test the extent to which the addition of ferrous sulphate would reduce the interaction between lime sulphur and lead arsenate, the amount of water-soluble arsenic produced by passage of air through the suspension until oxidation was complete, as judged by the disappearance of the yellow colour of the polysulphides, was determined. The spray without ferrous sulphide yielded 23.3mg. arsenic (expressed as As_2O_5) per 100ml., whereas that with ferrous sulphate gave only 0.93mg. soluble arsenic.

The optimum amount of ferrous sulphate to be used was based on the assumption that lime sulphur of polysulphide content of 18-20 per cent. W/W will contain, on the average, 4.5 per cent. W/W monosulphide sulphur. For each gallon of lime sulphur used, 5 lb. ferrous sulphate crystals will be required to precipitate the monosulphide sulphur.

(*b*) *Field Trials.*

(i) *Long Ashton* (*Plots 7b and* 11). In the field, the ferrous sulphate mixture was used in comparative trials with other spreader and oil combinations. Thus on plot 7*b* at Long Ashton, post-blossom sprays were applied, as previously described, to individual 12-tree rows of Worcester Pearmain, and the total of sawfly-infested fruits recorded. The following gives the results from the standard washes compared with that from the ferrous sulphate mixture.

Composition of Washes per 100 gallons wash.	*Total fruitlets.*	*Percentage sawfly infested fruitlets.*
Lime sulphur (1½ gal.)	3971	28.3
Lime sulphur (1½ gal.) Nicotine (8 oz.) Agral N (1 lb.)	4502	2.99
Lime sulphur (1½ gal.) Lead arsenate powder (300 mesh) (2 lb.) Nicotine (8 oz.) Agral N (1 lb.)	4500	8.3
Lime sulphur (1½ gal.) Lead arsenate powder (300 mesh) (2 lb.) Nicotine (8 oz.) Agral N (1 lb.) Ferrous sulphate (5 lb.)	6785	4.67

Neither in this trial nor in that on Plot 11, described under 2. (*b*), was there any indication of spray damage with the ferrous sulphate mixture.

(ii) *Overbury.* Post-blossom trials were carried out at this centre in a plantation of approximately 8 acres (1,485 trees) set out in 1922. The varieties were Cox, Worcester and Rival, with a few rows of Ross, Newton, Grieve and King of the Pippins. For the purpose of the trial, the trees were divided into six blocks (A to F) of approximately equal size. Spraying was carried out at petal fall (May 31st) and on June 7th, on the following plan :—

Block.	*Spray Mixture, May 31st.* (*per 100 gal.*)	*Spay Mixture, June 7th.* (*per 100 gal.*)
A	Arsenate powder (300 mesh) 2 lb. Nicotine .. .. .. 8 oz. Lethalate Wet. Prep. .. 8 oz.	Lime sulphur .. 1 gal.
D	ditto	Lime sulphur .. 1 gal. Nicotine .. .. 8 oz. Lethalate Wet. Prep. 8 oz.
E	ditto	ditto
F	ditto	ditto
B	Lime sulphur .. .. 1 gal. Arsenate powder (300 mesh) 2 lb. Nicotine .. .. .. 8 oz. Lethalate Wet. Prep. .. 8 oz. Ferrous sulphate .. 5 lb.	—
C	ditto	—

Examination on June 12th and during August showed no damage on any of the blocks. Attacks of sawfly and scab were very light, and no significant differences between the blocks could be found.

III. COMBINED WASHES ON BLACK CURRANTS.

1. Hydrocarbon Oils with Lime Sulphur.

(*a*) *Materials.*

The use of lime sulphur at the pre-blossom stage is a recognised method of obtaining big bud control on black currant, and the late application of petroleum oils as ovicides for capsid control would appear a promising alternative to the use of such oils as winter washes. The petroleum oil-lime sulphur combination was accordingly chosen for trial at two centres during 1934.

In one trial, the opportunity was taken to compare, in addition, the ovicidal properties of a petroleum oil of moderately high degree of refinement—a type technically termed half-white—with those of a semi-refined, cheaper petroleum of spindle oil type. Further, the influence of type of emulsifier upon ovicidal properties was examined by the use, in one spray, of Agral W.B. and, in a second, of oleic acid as the emulsifier.

The complete range of treatments tested was therefore as follows :—

A. (Control).
B. 4.25 per cent. high boiling tar oil, 4.25 per cent. semi-refined petroleum oil.
C. 4.25 per cent. high boiling refined petroleum oil, to which lime sulphur was added after emulsification.
D. 4.25 per cent. high boiling tar oil and 4.25 per cent. half-white petroleum oil.
E. Oils as in D.

The characteristics of the oils are given in Table II.

The tar and tar-petroleum oil mixture used in treatments B and D were emulsified by the two-solution oleic acid method (7), oleic acid being dissolved in the oil mixture and caustic soda in the water used for dilution in proportion to give 1 per cent. oleic acid and 0.15 per cent. sodium hydroxide in the final spray. In treatment C the oil was emulsified with sulphite lye (5) to give an emulsion containing 67 per cent. of oil by volume, and to the diluted wash, 8 per cent. lime sulphur was added before application. In treatment E, the oils were emulsified by the two-solution Agral W.B. method (11), the final wash containing 1.5 per cent. Agral W.B. and 0.1875 per cent. sodium hydroxide. All methods gave emulsions perfectly satisfactory for spray purposes.

TABLE II.

CHARACTERISTICS OF OILS USED IN SPRAY TRIALS.

	Tar Oil.	Semi-refined petroleum oil.	"Half-white" petroleum oil.	Refined petroleum oil.
% by weight.				
Neutral oils	88.6	100	100	100
Tar Acids	5.7	—	—	—
Neutral oils—				
Sp. Gr. (60°F.)	1.089	0.898	0.885	0.864
Viscosity—				
Redwood I at 70°F. ..	—	160″	146″	127″
Boiling Range—				
90% by vol. distil above	248°C.	348	328	323
50% ,, ,, ,, ,,	320	378	362	357
20% ,, ,, ,, ,,	370	394	392	384
Unsulphonated Residue—				
% by vol.	—	74	90	98

(b) *Field Trials.*

(i) *Ledbury.* A block of 625 bushes of the variety Baldwin was used for trial and divided into a Latin square each side of five sub-plots, each of 5 × 5 bushes. The arrangement of the treatments is shown in Table III. The tar and tar-petroleum oil washes (Treatments B, D and E) were applied on February 26th, 1934, in bright sunshine and a cold but quick-drying wind, by means of a small power machine operating two lances. About 35 gallons of wash were used for each 125 bushes. The petroleum oil-lime sulphur combination (Treatment C) was applied by the same men on April 10th, when the buds had broken but the flower buds were not open.

The degree of capsid infestation was estimated on June 7th by three observers who independently examined three of the nine inner bushes of each plot, counting the number of shoots showing capsid-marked leaves. On the unsprayed bushes (A), the total number of shoots was also counted. For convenience, the sum total of the counts of the nine bushes per sub-plot are given in Table III, which also shows the arrangement of sub-plots.

TABLE III.

E 14	A 475/933	C 28	D 23	B 24
D 0	E 56	A 462/1236	B 28	C 6
A 155/193	C 18	B 42	E 84	D 27
B 13	D 36	E 103 (8 bushes)	C 264	A 748/803
C 39	B 23	D 23	A 666/691 (7 bushes)	E 87

A statistical examination of the individual counts, omitting those for unsprayed plots, gave the following result :—

	Degrees of Freedom.	*Sum of (Deviations)*^{2}	δ^2
Treatments	3	1147.88	382.63
Blocks	4	2166.85	541.71
Observers	2	102.70	51.35
Error	170	7667.12	45.10

and indicated a significant difference between the degree of control given by the four treatments.

The results, expressed as the average number of capsid-marked shoots per bush, were :—

Treatment	B ..	2.89 capsid-marked shoots per bush	*Significant difference* =2.86.
,,	C ..	7.89 ,, ,, ,, ,, ,,	
,,	D ..	2.44 ,, ,, ,, ,, ,,	
,,	E ..	7.93 ,, ,, ,, ,, ,,	

As the average for the unsprayed bushes was 59.4 capsid-marked shoots per total of 101.7 shoots per bush, it is evident that all the washes were most successful in controlling capsid bug. The results indicate, however, that the Agral W.B. emulsion and the lime sulphur-petroleum oil combination are slightly less effective than the oleic acid emulsion. The substitution of the semi-refined petroleum oil for the more expensive half-white oil has not reduced ovicidal efficiency.

None of the washes caused any damage and there was no retardation of growth following the petroleum oil-lime sulphur mixture.

(ii) *Bredon.* At a second centre, a combined wash consisting of white oil emulsion (5 per cent. oil, emulsified with sulphite lye) and 6 per cent. lime sulphur was applied to 100 bushes of Baldwin black currants on April 14th. The bushes were then at the stage normally selected for the big bud spray and considerably more advanced than that reached by the bushes at Ledbury on April 10th. As a result of the spray application at Bredon. marked marginal leaf scorching was obtained and the growth of the bushes was checked. This damage was accentuated by a frost on April 23rd which caused some " running off " of the exposed racemes. The bushes remained backward until late in the season.

The control of capsid was estimated by counts of the damaged shoots on a large number of bushes selected at random from the experimental plots. The results were as follows :—

Unsprayed	100 per cent. infestation.
Sprayed ..	10.1 per cent. infestation.

thus showing that the combined wash gave a satisfactory control of capsid, but in view of the damage it would seem advisable to apply this mixture before the blossom trusses open. It was impossible from one season's observations to determine the control of big bud.

IV. COMBINED WASHES ON PLUMS.

(*a*) *Materials.*

The use of lime sulphur or of suitable petroleum oil emulsions at petal fall is known to give a satisfactory control of red spider on plums. At the same stage, caterpillar is controllable by lead arsenate. Within the past few years, attacks of plum sawfly have become increasingly serious and, from a consideration of the life history of this pest, it appeared that it might also be amenable to control at the petal fall stage. Trials were therefore carried out in 1934 to find a non-phytocidal combined wash that would simultaneously control red spider, caterpillar and plum sawfly.

In addition to the materials previously mentioned in this paper, use was made of a derris powder and of a " colloidal " lead arsenate.

(*b*) *Field Trials.*

(i) *Overbury.* Twelve acres of the following varieties of plums were sprayed on May 24th, approximately ten days after petal fall :—Belle de Louvain, Black Diamond, Czar, Merryweather, Monarch, Pond's Seedling, Prolific, Purple Egg, Victoria, Yellow

Egg. The ingredients of the wash, per 100 gallons, were as follows :—

Lead arsenate powder (300 mesh)	2 lb.
Lime sulphur	1 gal.
Nicotine	8 oz.
Lethalate Wetting Preparation	8 oz.

The trees were thoroughly sprayed and a good deposit of the wash was obtained on both surfaces of the leaves. The control of red spider and caterpillar was most satisfactory. The plum sawfly attack on the control trees was negligible and therefore no indication of the effectiveness of the spray against this pest could be obtained.

There were no signs of foliage damage on any of the varieties except on the trees of Purple Pershore which developed in mid-July the small red areas on the leaves characteristic of arsenical injury. These areas eventually dried out and the loss of leaf surface was reflected in an early fruit maturity and some loss of crop. Trees sprayed with lime sulphur and wetter only showed no signs of injury.

(ii) *Pinvin.* At this centre, trials were carried out on trees of the variety Czar. Double spraying was employed, and two types of wash were tested in the second application. For the first application, on May 11th, seven days after petal fall, the following mixed wash was used :—

Colloidal lead arsenate	2 pints.
Nicotine	8 oz.
Lethalate Wetting Preparation	8 oz.
Water	100 gal.

The second application took place on May 29th, when half of the trees previously sprayed on May 11th received the following wash :—

Refined petroleum oil emulsion (See Table II).	1½ gal.
Lead arsenate powder (300 mesh)	4 lb.
Water	100 gal.

The remaining half of these trees was sprayed on May 29th with a derris-arsenate wash of the following composition :—

Ground derris root (2% crystalline rotenone)	2 lb.
Lead arsenate powder (300 mesh)	4 lb.
Lethalate Wetting Preparation	8 oz.
Water	100 gal.

The control of plum sawfly was in no case satisfactory as the first wash was applied before oviposition was completed, while the second wash did not provide any material control of wandering sawfly larvae. The control of spider was satisfactory in both the types of treatment employed and no foliage damage was recorded.

SUMMARY.

Spray trials, carried out during the 1934 season on apple, currant and plum, with combined insecticide-fungicide washes gave the following results :—

1. No significant differences were observed in the degree of apple sawfly control obtained with nicotine-lime sulphur-spreader washes in which the following spreaders of declared composition were used : Agral N, Igepon T, Lethalate Wetting Preparation and Sulphonated Lorol, all at the rate of 8 oz. per 100 gallons. Sulphite lye (60°Tw.) at 6 pints per 100 gallons and crude calcium gamma-sulphonates at 24 oz. per 100 gallons also proved effective spreaders for apple sawfly control.

2. Refined petroleum oil (1%) and lime sulphur (1%) combinations were applied post-blossom to a number of commercial varieties of apple without causing spray damage.

3. The addition of ferrous sulphate to the lime sulphur-lead arsenate spray proved of promise. This addition, made at the rate of 5 lb. crystalline ferrous sulphate per gallon of lime sulphur concentrate, reduced the formation of soluble arsenate, obviated sludge production, rendered the spray deposit more clearly visible and increased its adherence. As the addition of ferrous sulphate also liberates as free sulphur the monosulphide sulphur of lime sulphur, it should further enhance the fungicidal efficiency of the mixed wash.

4. Refined petroleum oil (4.25%)-lime sulphur (8%) combinations were successfully applied to black currants at the pre-blossom stage for the simultaneous control of big bud and capsid bug.

5. Excellent control of capsid bug on black currants was obtained by the application of combinations of either semi-refined or " half-white " petroleum oil (4.25%) and strained anthracene oil (4.25%) as dormant washes. The substitution of oleic acid for Agral W.B. as emulsifier increased slightly the efficiency of the wash.

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THE CONTROL OF THE INSECT PESTS OF BASKET WILLOWS.

WITH SPECIAL REFERENCE TO THE USE OF COMBINED INSECTICIDAL AND FUNGICIDAL WASHES AND TO METHODS OF APPLICATION.

By H. G. H. KEARNS.

INTRODUCTION.

It is well recognised that the basket willow serves as the host plant for a very large number of species of insect. Critical observations have shown that with each species of willow there are associated definite insect species. In many instances a given insect is specific to one species of willow or to a group of willows possessing common chemical characteristics. For example, the Chrysomelid Beetle *Phyllodecta vitellinae* (Brassy Beetle), which feeds on *Salix purpurea*, will not attack *S. triandra*. On the other hand the aphides form an exception in that they are able to adapt themselves to a wide range of species. Only a few of the numerous insects on willows can be regarded of considerable and regular economic importance.

It is essential to grow basket willow rods as straight as possible and to avoid the production of side shoots during the principal growing period. The straight growth of the rod is very easily disturbed by slight insect injury, and for this reason there is no doubt that the various insects on the crop, although as individual species not attaining economic proportions, when considered together are responsible for a considerable loss of quality in rods.

The control of insect and fungus pests of willows in this country has never received the serious attention of growers. The control measures that are used are quite inadequate and constitute one of the main reasons for small returns from the crops. Research work has been carried out at Long Ashton on the major pests and diseases and practical control measures have been evolved, and it now remains for the results of this work to be applied in field practice.

The main objects of this article are to describe the principal pests of basket willows and to suggest practical methods for their control. In the latter connection the principles underlying control methods are outlined, the more important ingredients of sprays and dusts which may be used are described and reference is made to the special problems of spraying willow beds.

Since in evolving a programme against the major pests, it has been possible to introduce into the sprays and dusts used fungicidal materials which efficiently combat certain of the major fungus diseases, these latter together with the principles underlying their control are also briefly described and methods of incorporating suitable fungicides into mixed washes and dusts discussed.

The sprays and dusts described enable the grower to carry out a full programme with a minimum of applications.

THE PRINCIPAL PESTS AND DISEASES.

Each of the principal commercial species of basket willow are subject to different pests and diseases of which the more important are the following :—

A. Host : *Salix triandra* (*e.g.* Black Maul, Spaniards).
    Willow Aphides.
    Brown Beetle (*Galerucella lineola*).
    Button Top Midge (*Rhabdophaga heterobia*).
    Rust (*Melampsora amygdalinae*).
    Black Canker (*Physalospora miyabeana*).

B. Hosts : *Salix purpurea* (*e.g.* Brittany Green, Dicky Meadows).
  and *S. alba* var. *vitellinae* (Golden Willow).
    Willow Aphides.
    Brassy Beetle (*Phyllodecta vitellinae*).
    *Black Canker (*Physalospora miyabeana*).

C. Host : *Salix viminalis* (*e.g.* Mealy Top Osier, Long Skin).
    Willow Aphides.
    Willow Shoot Moths (*Depressaria conterminella*, *Peronea hastiana*, *Cheimatobia brumata* and other species).
    Blue Beetle (*Phyllodecta vulgatissima*).
    Rust (*Melampsora Larici-epitea*).

The insects mentioned above are species generally responsible for serious loss of crops. Locally, certain species, not mentioned above, may become of considerable economic importance. Thus the larva of the Willow Weevil (*Cryptorrhynchus lapathi*) may ruin a large number of two year old rods by tunnelling in the stem just above the head of the stool. At times the Stem Midge (*Rhabdophaga saliciperda*) is present in large numbers on the stools and the portion of the rods above the stools, and considerable damage is done by birds shredding off the bark in order to extract the cecid larvae. Flea Beetles in some dry seasons do a considerable amount of foliage damage on such species as *S. viminalis*, particularly if the attack occurs early in the season on young rods. Occasionally portions of a willow bed of *S. viminalis* and its hybrids may be partially defoliated by the attacks of the larvae of sawflies. In some localities capsid bugs and other sucking insects may be responsible for the presence of surface distortions on willow rods. It is unusual for any of the above pests to be widespread in a district, and in most cases some local factors have encouraged the development of the pest.

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* Attacks *S. alba cardinalis* severely, much less common on *S. alba vitellinae*.

The Willow Aphides. Willow Aphides may be divided into two groups according to whether they feed on the top growing portion or on the bark of the rods. There are a number of species and it appears that each species is able to attack a number of species of willows, although it is possible that further investigation will show that they are more specific than is generally supposed. *Aphis saliceti* and *Cavariella capreae* are the principal foliage feeders, and to a less extent *Pterocoma pilosa*. These aphides usually occur in numbers in June and July and under favourable conditions their reproduction is very rapid and the intensity of the infestation may be very severe.

The aphides occur principally on the upper portions of the rods, and by sucking the sap they check growth and frequently cause the formation of side shoots which render the rods of little value. In addition to this damage the insects produce quantities of honey dew, which falls on the foliage and hinders transpiration. In a severe attack the foliage is reduced to a greyish sticky mass, and results in an almost total loss of crop. Even a slight infestation has serious results and an attack must be controlled promptly before the aphides have had time to form large colonies.

There are two common species of large stem aphides, *Pterochlorus viminalis* and *Melanoxantherium salicis*. These aphides frequently exhibit a preference for the portions of the rods in the second season of growth, or the basal portion of the current season's rods. The attacks are most severe during the period August to October, and at times the whole of the rods may be completely covered with the aphides. If the attack is severe and commences early in the season, the check on growth is considerable, and at times the rods may be killed. The insertion of the sucking mouth parts of the aphides into the rod causes a stain to develop on the wood and the bark may be more difficult to peel. The enormous amount of indirect damage that can be caused by aphid attack is not fully appreciated, and in most cases control measures are not commenced early enough, nor are they carried out with sufficient speed.

Brown Beetle (*Galerucella lineola*). This Chrysomelid Beetle (4) often causes considerable damage to the crops of *Salix triandra*, varieties of which are extensively grown in Somerset. The pest tends to be rather sporadic in occurrence, the intensity of the attacks having been of little consequence during the past three years. A review of the pest in Somerset indicates that its economic importance tends to go in cycles, and after a period of years of slight infestations it suddenly becomes a major pest for several seasons.

There are two principal forms of injury, (i) the destruction of the developing shoots and buds on the stools in early spring by the adult beetles and, more usually (ii) the injury to the growing point and destruction of the top leaves of the developing rods by the adults and larvae.

The beetles in some seasons appear at the time of bud burst in spring and assemble in considerable numbers on the stools and consume the shoots as they develop. This form of injury causes fresh buds to develop and the crop does not completely recover even by the end of the season. If rods in their second year of growth are present on the bed they are attacked first as their foliage is more advanced. More usually, the beetles leave their hibernating quarters and appear in increasing numbers over a period of two or three weeks and, after feeding on the terminal portions of the young rods, they lay eggs in batches on both surfaces of the upper leaves during the first two weeks in June. After the egg laying is completed the adults die. The larvae may be found in numbers during the last two weeks in June. They feed on the upper leaves of the rod, the tissues of the entire leaves being consumed. The combined damage of the adults and the larvae cause the formation of side shoots with the result that the attacked rods are rendered worthless for basket making purposes. The damage caused by the larvae from one batch of eggs is sufficient to ruin a rod. A second brood of adults emerges during early August, and these beetles at times occur in enormous numbers and cause extensive defoliation. During still, sunny weather, they may fly from bed to bed and in this manner the pest becomes distributed. Occasionally a small partial second brood of larvae occurs, but more usually the adults from the June brood hibernate in the winter beneath rubbish in hedgerows and on the bed, etc. It is interesting to note that after floods the attacks are often severe where the rubbish has settled, no doubt due to the fact that the beetles were hibernating in it. Similarly, the early attacks of beetles in the spring often commence near the higher headlands and hedgerows.

Brassy Beetle (*Phyllodecta vitellinae*). This Chrysomelid Beetle (3) is often responsible for serious damage to *Salix alba vitellinae* and varieties of *Salix purpurea*. There are two broods of the beetle in the season, and the second passes the winter in hibernation. Usually the beetles leave their winter quarters in spring, when the young shoots on the stools are several inches long, and they congregate and consume the top leaves. Occasionally all the beetles emerge on approximately the same date before the shoots on the stools have developed. Under these circumstances, they attack any two year old rods on the bed or, in the absence of these, they remain on the stools and consume the shoots as they grow. In some seasons there is a mass migration to a fresh bed or beds. Eggs are laid in batches on the lower surfaces of the lower leaves in late May and June. The larvae only feed on the lower surfaces of the leaves and the entire leaf is skeletonised. In severe attacks the defoliation is considerable. A second brood of beetles occurs in early August and larvae occur in late August and early September. The combined attacks of the beetles and the larvae may result in complete defoliation of the rods.

In some seasons, particularly wet ones, there is considerable overlapping of the broods and occasionally there is a complete absence of a second brood, the first going into hibernation in late August and early September. Even attacks of moderate severity cause an appreciable loss of crop due to the rapid development of side shoots on the rods at the time of maximum growth.

The Blue Beetle (*Phyllodecta vulgatissima*). The Blue Beetle is confined principally to varieties of *Salix viminalis*. The life history and damage caused by the pest are very similar to that of *P. vitellinae*.

Button Top Midge (*Rhabdophaga heterobia*). The Button Top Midge (1) is in some seasons a serious pest of *Salix triandra* varieties. It resembles superficially a very small long-legged fly. There are two principal overlapping broods, the first emerging in May and the second in July. The eggs are laid in batches near the terminal buds of the rods and on hatching the larvae find their way into the buds which then fail in most instances to make any further terminal growth, a rosette of leaves being formed, hence the term " button top." The most serious damage is caused by the larvae hatching from eggs laid in June at the period when the rods are about to make their maximum growth. The attacked rods are rendered worthless.

Willow Shoot Moths. The principal species are *Depressaria conterminella* (the Willow Shoot Moth), *Peronea hastiana, Cheimatobia brumata* and other species which have not been identified in Somerset. Miles lists the species occurring in Lancashire (7).

The attacks are usually confined to varieties of *Salix viminalis,* the leaves of which are well adapted to the leaf spinning habits of some of the species of moths. *Depressaria conterminella* appears to be the most important species and the life history and a method of control of this pest has been described by Miles (7). The species is single brooded. The larva attacks the terminal portion of the shoots in spring when they are about a foot high. The leaves are bound together around the shoot by the larva and the surface of the enclosed shoot is damaged. The larva pupates in the soil and the moth lays its eggs on the stool in June and July.

Peronea hastiana is double brooded in Somerset and pupates in the folded leaves. The first brood larvae occur in early spring and these cause a similar type of damage to that of *D. conterminella.* The second brood occurs much later in the season but the damage is not of any serious consequence as the principal growth of the willow rods has been completed.

C. brumata at times is responsible for an appreciable amount of terminal shoot damage, the larva confining its attention to the folded up leaves.

Rust. (*Melampsora amygdalinae*). Rust is the major fungus disease of varieties of *Salix triandra.* The fungus has recently been identified by Ogilvie (5, 6), who has worked out its life history in detail. It is widely distributed in Somerset and must be considered the most serious disease. The presence of the disease is easily recognised in early spring by the presence of bright orange cankers or swellings on the lower leaves. Subsequently and throughout the summer, abundant orange pustules of summer spores are produced. The green stems are also attacked and the infected areas become hardened, misshapen and blackened with the result that the rods snap readily at these points. The fungus overwinters mainly by means of resting spores on the old leaves. The attacks are severe in most normal seasons, and it is only during abnormally dry seasons, such as those of 1933 and 1934, that the disease is of little or no importance.

Black Canker. (*Physalospora miyabeana*). This disease has been investigated by Nattrass (8, 9). The first symptoms of an attack of Black Canker are the formation of black areas in the leaves, which gradually increase in size and extend down the leaf stalk to the rod. The leaves finally fall off and the infected portions of the rod develop into black cankers. Frequently the terminal portion of the rods die back. The portions of the rods attacked by the canker are very brittle and these points of injury snap during the manipulations of basket manufacture. It appears (8) that all species of willows are liable to attack, but *Salix alba cardinalis* and varieties of *Salix purpurea* suffer most. *Salix triandra* is attacked but the attacks are of comparatively small importance as compared to those of Yellow Rust. *Salix viminalis* is the least subject to injury. Ogilvie (2) has found that the fungus also attacks pollard willows (*S. fragilis*) growing at the sides of the fields and that spores blown from these may serve as an important means of infection of the withy beds.

THE PRINCIPLES OF CONTROL OF WILLOW PESTS AND DISEASES.

It is seen from the brief descriptions of the life histories of the principal insect pests of basket willows, that any check to the growth of the rod, particularly during the period of May to July, has serious consequences in that it causes the development of side shoots and in the case of the fungus diseases the formation of cankers on the rods which snap at the places of infection. It is evident that the successful production of first quality rods depends on the control of both insect and fungus pests. The control of the one without the other is quite useless in most seasons. Unfortunately it is impossible to predict the intensity of either insect of fungus attack in a particular season, and particularly in the case of fungus diseases it is imperative to carry out protective control measures.

The majority of the basket willow rods are of one season's growth, and it has been found in these circumstances that if the crop is protected from injury during May, June and early July, there is every chance of producing a crop consisting largely of clean rods.

The insect pests are killed either by toxic substances coming into intimate contact with them or by their consuming poisoned foliage. The first group of substances, known as the contact insecticides, include oil emulsions, nicotine, derris and pyrethrum preparations. The second group consists of stomach poisons such as lead and calcium arsenates, barium silicofluoride and probably derris preparations.

Fungus diseases are controlled by covering the foliage with a film of a chemical toxic to spores. It is important to note that a fungus established on the plant tissues cannot be killed by the surface application of fungicides. The only satisfactory method of preventing a fungus attack is to cover the plant tissues with a protective film, so that spores coming into contact with the leaves and stems are killed on germination.

The most effective fungicides consist largely of copper and sulphur preparations.

INSECTICIDES AND FUNGICIDES SUITABLE FOR APPLICATION TO WILLOWS.

Insecticides.

Nicotine. Nicotine preparations, as used in this country, consist of free nicotine of 95—98% purity, made up either in the form of washes or dusts. Nicotine acts as a contact and fumigant poison, and it is essential in most instances for it to come into intimate contact with the insects. For this reason, when it is used as a wash, it is necessary to add a spreader to the water to ensure that the liquid is evenly distributed over both insects and foliage. It is desirable for the foliage to be wetted in order to increase the chances of the wash spreading and thereby coming into contact with insects feeding in protected positions.

One of the most commonly used spreaders is soap, but this cannot be used economically with very hard waters, such as are found in the dyke waters of the Somerset moors, and it is necessary to use special wetters of high efficiency such as the proprietary preparations Agral "N" or "2," Lethalate Wetting Preparation, Sulphonated Lorol, etc. These wetters at suitable concentrations enable the full toxic properties of the nicotine to be used to the best advantage.

Nicotine washes control the larval stages of the Brown Willow Beetle, some of the Willow Sawflies (*Pteronidea* spp.), Aphides and the adult stages of the Willow Midges. They do not provide a satisfactory control of the larvae of the Blue and Brassy Willow Beetles, unless the larvae have just hatched or the concentration of the nicotine be high (10 oz. per 100 gals.). Adult beetles are not killed by the usual nicotine sprays.

The following formula is recommended :—

4–6 fl. oz.	Nicotine (95–98%).
½ lb.	Agral " N " *or* " 2," *or* Lethalate Wetting Preparation *or* equivalent wetter.
100 gals.	Water.

Nicotine can be purchased in combination with special soaps and wetters. It is essential to ascertain the amount of nicotine (expressed as free nicotine) in these materials so that the correct amount can be used to provide a wash containing 4–6 oz. nicotine per 100 gallons water.

Dusts consist of free nicotine incorporated with various carriers such as kaolin, ground mineral phosphates admixtures, etc. The concentration of the free nicotine varies between 2–5 %. Dusts in their present form do not provide satisfactory results on willows, the materials failing to adhere to the smooth foliage of such species as *Salix triandra.*

Derris. Derris is sold in this country principally in the form of finely ground derris root and dusts, but it may be obtained in the form of extracts and used in emulsions. The principal toxic constituent of derris is rotenone, which is highly toxic to many insects but not to man or domestic animals. Very low dilutions will kill fish. It has important advantages over pyrethrum preparations in that its toxicity is effective for several days after application and it does not readily decompose on storage. It has a wider range of toxicity than lead arsenate and nicotine.

Derris washes usually consist of ground derris root used in conjunction with soft soap or a wetter such as those mentioned as suitable for nicotine.

The following wash is recommended :—

*2½ lb.	Derris (1.5% crystalline rotenone).
½ lb.	Wetter (best suited for hard waters).
100 gals.	Water.

Derris dusts consist of a carrier to which ground derris root or an extract is added. They should contain not less than 0.15% crystalline rotenone.

Dusts provide a satisfactory control of the adults of the Blue and Brassy Beetle (*Phyllodecta* spp.) and the larvae and adults of the Brown Beetle. The best results are obtained when the beetles have collected in considerable numbers on the shoots and young leaves in early spring. At other times of application dusts do not give satisfactory results.

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* The amount of derris required per 100 gallons of water must be adjusted according to the rotenone content. The wash should contain not less than 0.004% crystalline rotenone.

Derris may be used in conjunction with Bordeaux mixture.

Pyrethrum. Pyrethrum is a powerful contact insecticide and causing paralysis of insect muscles. It is non-poisonous to man and animals. It is best used as an extract prepared from *Pyrethrum cinerariaefolium* or *P. carneum* or *P. roseum* and made up in the form of an emulsion. It has been found that a wash at a concentration representing 1.0% of high grade flowers gives a high control of willow aphides and the larvae of the Brown Willow Beetle and *Pteronidea* Sawflies. It does not provide a high control of the larvae of the Blue and Brassy Willow Beetles, as these are protected from its toxic action by a glandular product secreted by these insects Under field conditions, it is most difficult to kill the abovementioned beetles by means of washes as they fall from the host plants before a sufficient amount of the fluid has come into contact with them.

Pyrethrum preparations have not been used successfully in conjunction with the fungicides Bordeaux mixture and lime sulphur in so far as the Willow pests are concerned.

It has been claimed that pyrethrum washes, after application, retain an effective duration of toxicity for several days. This has not proved to be the case with willow insects, and for all practical purposes the residual toxicity is negligible one day after application.

The high price of reliable preparations prohibits their extensive use in this country. It is advisable to purchase fresh stocks of material each season as the toxic principles, the pyrethrins, tend to decompose on storage.

Arsenicals. Lead and calcium arsenates are extensively employed for the control of foliage eating insects. Lead arsenate is exclusively used on fruit in this country, as it is less soluble in water than the calcium salt and consequently less liable to cause damage to foliage. In experiments it has been found that calcium arsenate can be used with safety on basket willows.

Lead arsenate can be purchased in three forms, powder, paste and colloidal. The arsenates are practically insoluble and very heavy, with the result that they sink rapidly. For this reason it is desirable that the size of the particles shall be as fine as possible in order to obtain a satisfactory suspension that can be sprayed uniformly over the foliage. Willow foliage, particularly that of varieties of *Salix purpurea* and *S. triandra*, cannot be wetted uniformly with water. The liquid collects in droplets or runs off, and therefore an arsenical wash is very badly distributed on the foliage unless a suitable spreader is employed to reduce the high surface tension exercised by the leaf surfaces. It has been found in experiments at Long Ashton that the wetting preparations Agral " I " or " N ", Lethalate Wetting Preparation, and low concentrations of White Oil emulsions provide uniform dispersion of lead arsenate on willows. The concentration of the wetter must be carefully adjusted according to the particle size of the arsenate. An excess of wetter may be easily added unless care is exercised, and this results in a markedly reduced deposit of arsenate on the foliage. When using a proprietary wetter with lead arsenate (and with Bordeaux mixture) it is advisable to carry out a preliminary experiment in order to ascertain the optimum concentration to be used. The following procedure is suggested. Two or more lots of lead arsenate wash should be made up containing the same quantity and make of arsenate, and to each lot a different amount of wetter should be added. The washes should then be applied to a small area of willows and that which, on drying, gives the greatest apparent deposit of arsenate on the foliage should be selected as suitable for making up the bulk required. Usually the concentration of wetter that just enables the foliage to be completely wetted gives the best results in so far as the arsenate is concerned. The following formula is given as a guide to the suitable contents of a wash :—

2 lb.	Lead Arsenate (powder) (approximately 300 mesh).
$\frac{1}{4}$–$\frac{1}{2}$ lb.	Agral " N " *or* "2," *or* Lethalate Wetting Preparation *or* an equivalent wetter.
100 gals.	Water.

If colloidal lead arsenate is used not more than $\frac{1}{4}$ lb. of the above-mentioned wetters should be used per 100 gallons of water.

The adherence of the above wash is most satisfactory, and in one experiment it persisted over a period of three months despite nearly continuous rainfall. It was ascertained by biological tests that the toxicity of the deposit on the leaves was considerably reduced four weeks after application and that this was due partly to the volatilisation of the arsenic.

An " oil bound " lead arsenate wash consisting of 1% white petroleum oil emulsion (0.6 gallon refined White Oil* emulsified by sulphite lye) and 2 lb. lead arsenate powder per 100 gallons provides an excellent cover and adherence to the foliage of *Salix triandra*.

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* Specification may be obtained on application to Long Ashton Research Station

One of the great advantages of lead arsenate in so far as the control of biting insects is concerned is that it remains toxic for a considerable period after application. This duration of toxicity is an important factor in the successful control of the Willow Beetles (*Phyllodecta* spp. and *G. lineolata*), as it permits of a longer effective spraying period. Thus a wash may be applied towards the end of the egg laying period of the beetles and the larvae on hatching will be killed after consuming the poisoned foliage.

Fungicides.

Copper fungicides such as Bordeaux mixture are best suited for the control of fungus diseases of willows. They may be applied in the form of washes or as dusts (copper lime dusts). Experiments with fungicidal dusts indicate that they give inferior results to washes except in special circumstances and this applies equally well to the use of insecticidal dusts. For example, dusts provide excellent results when they are applied to stools in spring about the time of bud burst. Dusts, however, do not adhere very well to willow foliage and, in addition, the abundance of foliage of a basket willow crop does not permit of the uniform distribution of a dust. The forceful application of a wash aids considerably in its distribution.

Wetters and Spreaders.

One of the greatest problems in dealing with the control of the pests and diseases of willows has been the difficulty of wetting the foliage, particularly of varieties such as those of the *Salix triandra* species. It is impossible to obtain the uniform distribution of an insecticide or fungicide unless special wetting material is added to the washes. For example, lead arsenate suspended in water collects in irregular patches on the edge of the leaves, or it may run off the foliage. Ordinary spray soap is used extensively as a wetter in nicotine and derris washes, but it cannot be used with Bordeaux mixture or arsenicals, nor with hard water containing calcium and magnesium salts, such as that occurring in the Somerset Moors. Other spreaders, such as calcium caseinate, saponin and gelatin, (more correctly described as a sticker at low concentrations) have been employed, but their efficiency is not very high unless high concentrations are used.

During the last five years a number of " wetting out " agents have been evolved for use in the textile industry, and some have been found suitable as substitutes for soap, etc., in sprays. Of these preparations, sulphonated compounds of naphthenic and aromatic hydrocarbons and compounds produced by the sulphonation of the saturated higher fatty alcohols have been used successfully on willows. They possess the most valuable property of being compatible with all the common insecticides and fungicides, and thus it is possible by their use to make an efficient mixed wash of nicotine, lead arsenate and Bordeaux mixture.

A number of new wetters are now sold by insecticide manufacturers under various proprietary names.

CRITICAL STAGES FOR THE APPLICATION OF INSECTICIDES AND FUNGICIDES.

Under the section dealing with insecticides and fungicides mention has been made of their toxicity towards the major willow pests. The following table shows the principal pests of various species of willows and indicates the optimum periods for carrying out control measures. These recommendations are intended for crops consisting of current season's growth and are not practicable for crops in their second or third year.

The growing season of the basket willow can be conveniently divided into five periods for the purposes of pest control. The periods suggested are those which in most seasons will be correct for the pests mentioned in the table. In some seasons adjustments must be made according to the intensity of attack of a particular pest or pests.

It is evident from the table that the optimum periods for the control of several pests occur at the same time and obviously it is more convenient and economical to control, if possible, all the pests with a combined wash possessing the necessary insecticidal and fungicidal properties.

TABLE I.

Showing the Principal Optimum Stages for the Application of Insecticides and Fungicides for the Control of the Major Pests and Diseases of Basket Willows.

Species of Willow.	Stage I	Stage II	Stage III*	Stage IV	Stage V
	Early Mid-April. (bud burst).	Early to Mid-May. (6in. shoots).	Mid-June.	Mid to end July.	Mid-August.
Salix triandra ..	Brown Beetle (adult) Rust	Rust Button Top Brown Beetle Black Canker	Rust Brown Beetle (eggs, larvae) Button Top Aphides Black Canker	Rust Stem Aphides Button Top Black Canker	
Salix purpurea .. *S. alba* varieties ..	Black Canker Brassy Beetle (adults)	Black Canker Brassy Beetle (adults)	Black Canker Brassy Beetle (larvae) (to end June) Aphides		Brassy Beetle (larvae) (Second brood)
Salix viminalis ..	Blue Beetle	Willow Shoot Moths Blue Beetle	Sawfly (larvae) Aphides Blue Beetle (larvae) (to end June)	Stem Aphides	Blue Beetle (larvae) (Second brood)

* The most important spray stage.

A number of experimental washes and dusts have been tried out at Long Ashton with this end in view, and the results are embodied in the following recommendations :—

TABLE II.

Stage of Application.		Spray Material.
Stage I.	Bud-burst	Copper lime dust. Derris dust. (Separately or in combination).
Stage II.	Early to Mid-May	Combined Wash consisting of :— Bordeaux mixture (10 lb. copper sulphate, 10 lb. quicklime, 100 gals. water). Wetter* (according to makers' instructions). 6 oz. nicotine (98%) (on *S. triandra* vars.). 4 lb. lead arsenate powder.
Stage III.	Mid-June	Combined Wash consisting of :— Bordeaux mixture (as in Stage II). 6 oz. nicotine. Wetter* (according to makers' instructions). 2 lb. lead arsenate powder.
Stage IV.	July	Combined Wash consisting of :— Bordeaux mixture (as in Stage II). Wetter*. 6 oz. nicotine (if stem aphid present).
Stage V.	Mid-August	2 lb. lead arsenate powder. Wetter*. 100 gals. water.

* See section on wetters and spreaders.

At the stage of bud-burst, it is frequently impossible to apply a dust or wash to a stool bed on account of the land being flooded or still too soft after flooding to permit the use of any horse-drawn spraying implement. In these circumstances dust can be applied efficiently and rapidly by means of hand rotary blowers as soon as conditions permit of satisfactory application. A combined dust consisting of copper lime and derris may be used instead of applying the copper lime and derris dusts separately, but it is desirable to use a factory prepared dust.

Stages II and III, especially the latter, are the most important spray periods, and every endeavour should be made to apply the recommended washes at these periods even if the other periods are omitted. At Stage II, lead arsenate need only be used on *S. viminalis* varieties (Mealy Top, Brown Merrin, Long Skin, etc.) if the attacks of the Willow Shoot Moths have been evident in the previous season. It is essential that the wash be applied as soon as the first symptoms of leaf roll are observed and 4 lb. of lead arsenate powder are recommended instead of the usual 2 lb. as a liberal covering of the foliage is desirable.

The addition of the nicotine at Stage II is recommended on *S. triandra* varieties, as it will kill the Button Top Midges which are sometimes present in numbers at this period, though it should be noted that the emergence of the Midges occurs over a long period and therefore the nicotine can only kill a limited number of the total population on a willow bed.

At Stage II, the time of application must be adjusted according to the condition of beetle infestation (Brown, Blue or Brassy Beetles). The best results are obtained in the case of the Brown Beetle if the wash is applied as soon as a number of the eggs have hatched but before any material larval damage has occurred. The nicotine will kill the larvae that have hatched and the lead arsenate will control the larvae that hatch after the spray application. The Blue and Brassy Beetles are best controlled by a spray application as soon as the majority of the eggs have been laid and before they have hatched.

Stage IV is the period of maximum growth of the rods, and in damp seasons which are favourable to the rapid development of Rust on *S. triandra,* it will be advisable to give a final application of Bordeaux mixture and nicotine. The nicotine will help to control Stem Aphides and also may check Button Top Midge.

Stage V is intended for varieties of *S. purpurea* and *S. viminalis* when they are attacked by the second broods of the Brassy and Blue Willow Beetles respectively. The wash must be applied to the lower surface of the middle and lower leaves on the rods before any extensive larval damage occurs.

In many instances, especially in the varieties of *S. viminalis*, it is not practicable to spray the crops at this period of the year on account of the height of the rods, and this is another reason why every endeavour should be made to carry out the recommended programme at Stages II and III.

METHOD OF PREPARING THE MIXED WASHES.

A complete combined wash may contain the following spray materials, Bordeaux mixture, nicotine, lead arsenate, wetter and water.

The Bordeaux mixture consists of 10 lb. copper sulphate (98% purity), 10 lb. best quality quicklime* and 100 gallons water. The copper sulphate and quicklime are best prepared as stock solutions.

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* 14 lbs. hydrated lime may be used instead of quicklime.

Forty pounds of granulated copper sulphate crystals are dissolved in 40 gallons of water, and as the crystals take some time to dissolve in cold water frequent stirring is necessary. Hot water, if available, greatly facilitates the operation. In any case it is best to make up the solution the day before it is required. The quicklime should be prepared on the day of use. 40 lbs. are carefully slaked by adding small quantities of water at intervals until all the lumps have broken up into a fine powder. The slaked material is then made into a cream with more water and finally diluted to 40 gallons.

One hundred gallons of wash of the correct concentration are prepared by taking 10 gallons of the recently agitated hydrated lime solution (containing 1 lb. of lime per gallon), and passing it through a fairly fine gauze filter, adding 80 gallons of water, and finally slowly adding 10 gallons of copper sulphate solution. The interaction between the copper sulphate and the slaked lime results in the formation of a gelatinous precipitate which should not settle readily. It is important that free copper sulphate should not be present, which is unlikely if good quicklime has been used. If a clean piece of tin or steel is held in the wash for a minute and a copper deposit is formed on the surface of the metal, it indicates that insufficient slaked lime has been used (and more must be added to avoid foliage damage). A suitable quantity of a wetter in solution is added to the mixture and it should be noted that amount must be carefully adjusted in order to obtain a complete wetting of the foliage and shoots and yet avoid the risk of reducing seriously the amount of deposit on the foliage (see note on lead arsenate). Some proprietary wetters cause considerable frothing of the mixture when continually agitated in the spray tank or returned to the tank after passing through the pumps.

Finally, nicotine and lead arsenate are added, the latter in the form of a cream prepared by mixing the powder with some water. The complete wash must be thoroughly agitated before use and applied on the day of preparation.

METHODS OF APPLICATION OF WASHES.

There are four possible methods of applying washes to basket willows (excluding 2 year or older rods) :—

(1) Knapsack pumps.
(2) Horse-drawn potato sprayers.
(3) Headland pumps and other mobile hand units.
(4) Power-driven outfits.

Knapsack Sprayers.

Knapsack sprayers are almost exclusively used for the application of washes to willows in Somerset, and the results are most unsatisfactory. The spraying is carried out very slowly, and the foliage is inadequately sprayed. It is impossible to spray a large acreage by this means within a short period, which is essential to deal effectively with many of the pests.

Potato Sprayers.

Horse-drawn and driven sprayers consist of a large capacity tank mounted on an axle with two large diameter driving wheels. The tank is fitted either with an external or internal pump driven by suitable gearing from the road wheels. The spray fluid is projected from a number of jets fitted to a horizontal bar at the rear of the machine. The axle must be adjustable to enable the wheels to go between the rows and a bar is fitted so that the rods are bent down during the passage of the outfit. It is necessary to have a suitable sized headland to permit of easy turning.

This method of spraying enables the work to be carried out quickly and very much more efficiently than is possible with knapsack sprayers, but this type of outfit is not well adapted for the uniform spraying of willow foliage.

Headland Pumps.

The possibility of using headland pumps has not received the attention it deserves from willow growers. The price of a complete outfit is about £25, and it is a possible substitute for a small power outfit and quite suitable for small growers. The unit consists of a pump mounted on a small trolley, preferably fitted with balloon tyres. The pump is hand operated on a lever principle, and the fluid is sucked from a container and driven by the pump into varying lengths of hose. It will maintain a working pressure of 120–150 lb. per square inch to a spray lance and can deliver $1\frac{1}{2}$ 2 gallons of fluid per minute. It is essential for its efficient use to have alleyways through the crop, to enable easy movement of the spraying plant and barrels of wash.

Power Outfits.

Modern power outfits have not been used on commercial willow beds, although it appears that the power application of mixed washes will provide the only completely satisfactory method of obtaining a control of willow pests.

The use of power outfits on a willow bed introduces a number of problems, and it is essential that the lay-out of the bed should permit of the full use of the benefits of power spraying. The production of basket willows depends largely on the successful control of pests and there is no doubt that beds in the future must be laid out with the definite intention of spraying them.

The following lay-out and outfits are suggested, as being suitable for most willow beds.

The willow bed may be divided into parallel alleyways by removing or omitting at intervals one row of stools so that from each alleyway the crop could be sprayed. The number of alleyways required would depend on the capacity of the spray outfit. A medium sized modern pump would be able to project a fluid up to 20 feet horizontally, and it is calculated that it would be possible to spray effectively 8 rows of willows planted at 2 feet apart. In these circumstances it would necessitate an alleyway after every 16th row.

The willows on either side of the alleyways would tend to grow "rough," but the loss would be more than compensated by the large increase in quantity of first quality rods of the crop.

In addition to the alleyways it is necessary to have suitable headlands or intermediate headlands through the beds, to permit of turning the machine and arranging a convenient supply of spray material.

The most suitable type of plant must be light in weight and in draught. A light chassis, such as that of a car trailer with balloon tyres and an adjustable axle, with a spray pump and engine mounted on it, will suffice.

There are several alternative methods of managing the spraying outfit in the willow bed. For example :—

(1) At regular and suitable intervals along the alleyway barrels of wash could be deposited. The spray pump would be placed near a barrel and from this centre the crop sprayed. The operator could work a spray gun from a length of hose sufficient to cover the crop on either side of the alleyway between two barrels of wash. In this manner section after section of the crop would be sprayed.

(2) The pump and spray liquid could be kept at the headlands and the wash pumped along steel mains laid in the alleyways. The mains would be fitted with cocks at suitable intervals, so that a length of hose could be fitted and the crop in the vicinity sprayed. This method is extensively used for spraying fruit trees and it has much to commend it.

A double set of mains would permit of continuous spraying, the second set being laid down whilst the first was in use.

This system necessitates a greater capital outlay than other methods of spray application, but in view of the long life of a willow bed, it would appear to be the most satisfactory method in the long run. It is important that a pump and engine of ample size are used for this type of plant, as the internal friction of long lengths of main is considerable.

Local growing conditions vary considerably and the above suggested methods of spray application may require modification to suit each particular case.

SUMMARY.

1. The life histories and biology of the principal pests and diseases of basket willows are outlined.

2. The properties of the principal insecticides and fungicides in so far as they refer to willow pests are given.

3. The value of combined washes possessing insecticidal and fungicidal properties is discussed and a spray programme designed to control the major pests and diseases suggested.

4. Present methods of spraying willows are summarized and suggestions are made for power spraying.

ACKNOWLEDGMENTS.

Thanks are due to Mr. L. Ogilvie, Advisory Mycologist, for his criticism of the mycological aspects of this paper, and to Mr. H. P. Hutchinson, Willow Officer, for ready assistance and criticisms throughout the investigations at Long Ashton on the insect pests of willows.

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THE CONTROL OF THE BRASSY WILLOW BEETLE—*Phyllodecta vitellinae* L.

WITH SPECIAL REFERENCE TO THE USE OF DUSTS.

By H. P. HUTCHINSON and H. G. H. KEARNS.

The Brassy Willow Beetle (*Phyllodecta vitellinae*) is a serious pest on basket willows, *Salix alba vitellina* and all varieties of the species *Salix purpurea* being specially subject to its attack. At times, the beetles collect in large numbers on the stools at the time of bud-burst, and do a considerable amount of damage by destroying the buds. Later, when the rods are growing, both adults and larvae feed extensively on the foliage and cause the formation of side shoots. The beetle rarely flies. Usually it is only found on the wing when leaving or seeking hibernating quarters. Its normal method of movement is by walking. It is very easily irritated and falls to the ground from foliage on slight disturbance.

In the course of research on methods to control this pest previous experiments with a pyrethrum dust (1), which consisted of a freshly prepared pyrethrum extract incorporated in a carrier in such proportions that ten parts of mixture contained the active principles of one part of high grade flowers, showed that this mixture did not provide a control of the adults. This failure was due to the difficulty of obtaining an effective adhesion of sufficient dust to the insects. Under field conditions the small amount of dust that adhered to the beetles was insufficient to kill or to paralyse them. Moreover, the dust that settled on the ground failed to have any effect on wandering beetles one day after application. Further experiments with dusts of increased concentrations of pyrethrum extracts led to the conclusion that the use of pyrethrum dust was not economically satisfactory, owing mainly to the high cost of the extract. It was also shown that the duration of toxicity after application was not satisfactory.

In view of the above results, further experiments on the control of the beetle have been carried out, using derris dusts instead of Pyrethrum. The experiments have shown that derris dusts provide a high control of the beetles, and it is now possible to put forward a programme of treatment that will provide a control of the beetles by dusting and of the larvae by means of a lead arsenate wash.

Experiments with Derris.

1. *Contact Action.* For experimental purposes a proprietary dust, consisting of ground derris root and a carrier, with a crystalline rotenone content of 0.18 per cent. (Roark's method) was used. The material was a fine dust and easily distributed by means of a Niagara type of hand blower.

449 beetles were collected from a willow bed and batches of 50 were lightly shaken in petri dishes with a small quantity of the derris dust. Immediately after this treatment they were placed in clean dishes. The following day 98 per cent. were dead.

This experiment showed that the dust was highly toxic to the beetles provided it came into intimate contact with them.

As a result of the above experiment further observations were carried out on a willow bed of *S. alba vitellina.* A block of 35 stools infested with beetles were dusted on May 30th, and on the following day the stools and soil were examined. The dust had settled on the bark of the stools and on the soil surface, but very little was evident on the foliage. 751 dead beetles (it was impossible to ascertain the exact number of dead beetles as many were hidden by soil or debris) were counted on the surface of the soil at the base of the stools, and only three living beetles were *present on the plants.* No dead beetles were observed on an adjoining untreated block of 25 stools on which 459 beetles were counted.

2. *Duration of Effective Toxicity.* In a second experiment, a stool and its shoots and adjacent soil were lightly dusted with the dust, and then covered with muslin to form an insect cage. 128 beetles were introduced into the cage. The following day all the beetles were dead. On the same stool, three days after the dust application, a second batch of 150 beetles was added to the cage, and of these 127 were dead on the following day.

3. *Influence of Carrier.* The failure of the pyrethrum dust (1) to control the beetles had suggested that the result was due to the poor adhesion of the carrier, kaolin, to the insects. An experiment was therefore carried out, using kaolin mixed with the finely ground derris root, in order to ascertain if the efficiency of the derris was affected. In order to compare the results with those obtained with the proprietary dust, the kaolin was mixed with the derris root in such proportions as to give the same content of crystalline rotenone.

The results obtained from this experiment showed that the kaolin preparation gave a 100 per cent. kill of the beetles, despite its poor adhesion, and the results from its use were similar to those obtained with the proprietary dust.

It may be concluded from the above experiments that derris is much more toxic to the beetles than pyrethrum when used in dust form.

Conclusions.

The results of the experiments show that a satisfactory control of the Brassy Beetle—*Phyllodecta vitellinae*—can be secured by the use of a derris dust.

Under dry weather conditions, the powder after application retained sufficient effective toxicity to kill or to repel wandering beetles for at least three days.

Recommendations for the Control of the Brassy Beetle by means of Derris Dusts.

The use of derris dust of a crystalline rotenone content of 0.18 per cent. is recommended as suitable for the treatment of willow stools, at and just after the time of bud burst and before the shoots have attained a length of 18 inches, to provide an efficient control of the willow beetle.

The powder should not be used at later stages of growth owing to the protection which the density of the foliage gives to the beetle. At these later stages a lead arsenate wash incorporating a wetter must be employed as a means of controlling the larvae (1, 2).

In some seasons when the beetles leave their hibernating quarters at different times, extending over periods of two or more weeks, several applications of the dust might be required.

It should be noted that a control of the beetles by treatment in spring will prevent or check any attack which might otherwise occur later in the season.

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THE CONTROL OF PHYLLOPERTHA HORTICOLA L. IN GRASSLAND.

By C. L. WALTON.

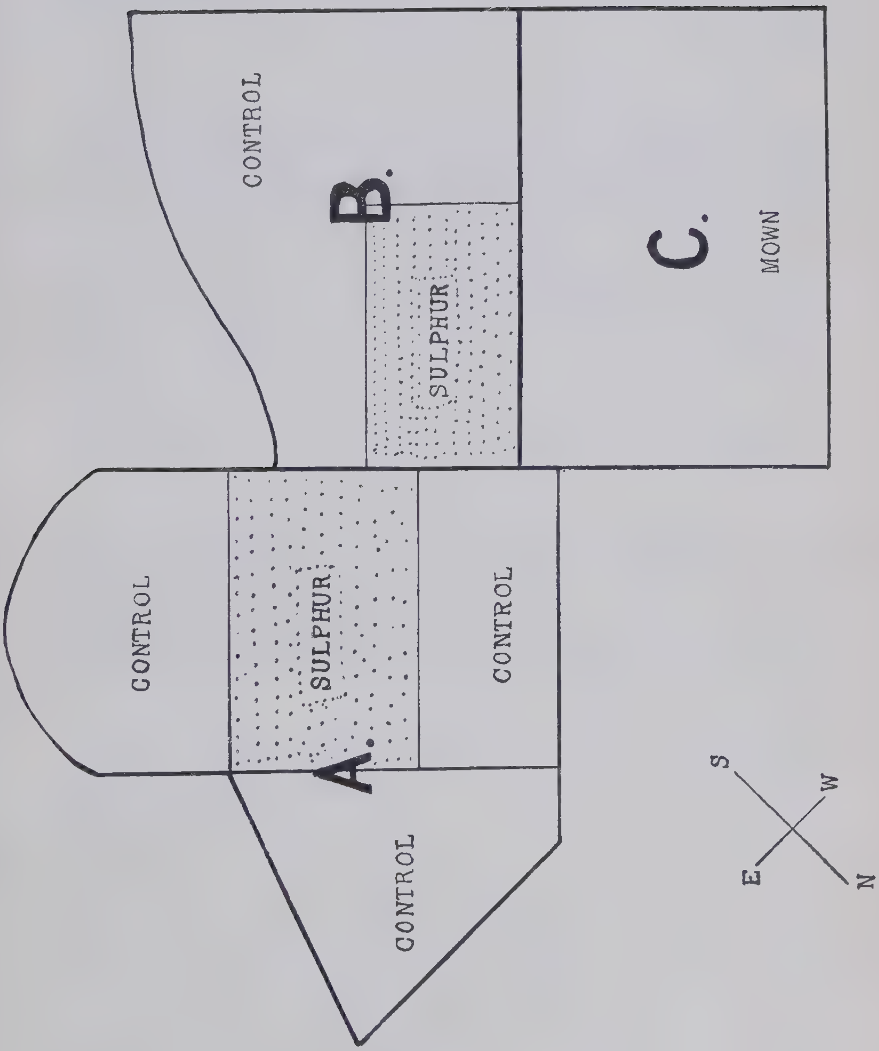
Introduction.

In the autumn of 1932, attention was drawn to a severe infestation by the larvae of *P. horticola L.* on pasture land near Yeovil, Somerset. Investigation showed two infested fields, comprising 20 acres of rich old pasture on a light sandy soil, with a southerly aspect and sloping down to a stream. There was no history of previous infestations, and the first signs of injury were noted in 1932. The damage done was very considerable on some 8 or 9 acres in particular, where the grass was to a very large extent destroyed. Rooks visited these fields in great numbers and it was largely due to this that the infestation was discovered.

In 1933, the infestation extended into yet a third field adjoining and above those originally attacked. The lay out of these fields is shown in the Diagram. Whether this infestation arose through a natural increase on those fields, due to especially favourable conditions, or through migration from other breeding grounds, is not known. No other attacks have been heard of in the neighbourhood ; there is, however, a considerable area of rough, bracken covered land in the vicinity, and it would seem certain that these heavily grassed slopes of warm light soils offer attractive and ideal conditions for these beetles.

It had been the custom of the tenant to graze these three fields during autumn, winter and spring and then to mow them, heavy crops being usual.

Of the three fields affected, the first (A on the Diagram) consisted of 11 acres of grassland, fairly level above and with slopes to the south and south-east, and about five acres below which are relatively level. These lower levels were only lightly infested, the larvae being chiefly massed on the slopes. A further grass field by the river was not attacked. Field B adjoins A, from which it is separated by a high bank, and consists of 9 acres, the whole sloping steeply. Some five acres of this field (adjoining field A) were very heavily infested, and the remainder less so. Field C,


CONTROL
B.
SULPHUR
C.
MOWN
CONTROL
SULPHUR
CONTROL
A.
CONTROL
S
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comprising 8 acres, lies above B and is fairly level. In 1933 those portions abutting on A and B were lightly infested.

As regards the numbers of larvae present, estimates made by the writer, and by the tenant and the estate agent would indicate roughly from 870,000 to 1,300,000 larvae per acre on the worst infested areas.

Experiments on the control of the beetle were carried out during 1933 and 1934. In these an autumn dressing of crude naphthalene efficiently controlled the larvae, whilst the substitution of close grazing for mowing substantially decreased the infestation. Results with sulphur as a deterrent to oviposition were inconclusive.

The Beetle, Its Life History, etc.

Phyllopertha horticola is commonly known as the Garden Chafer and also by a number of local names such as " Maybug," " Bracken-clock," etc., etc. In the adult stage it has a length of 7 to 10 mm. and is the smallest of the four species of " Chafer " beetles most commonly met with. All are at times of economic importance, the larvae causing serious losses to agricultural and horticultural crops.

Adult characters: Rather flattened with a greenish metallic shine. Head anteriorly rugose, posteriorly with large punctures; antennae reddish, club black. Thorax narrower than elytra, coarsely punctured, scutellum black. Elytra reddish brown, rather shiny, with dark suture and some indeterminate lines. Legs black, male with one claw dilated.(1)

The larvae very much resemble those of the well-known Cockchafer, but are on a much smaller scale: the body is similarly curved, yellowish white in colour, with the head darker; there are a few brown hairs on the body. The larvae are comparatively active and feed on the roots of grasses, and also occasionally on rose and fruit trees.

The adult beetles appear about mid-June and feed upon docks, clover, etc., and also bracken tips. The eggs are usually laid in grassland and the larvae feed for about eight months, when pupation takes place. As a pest of pasture land they cause very serious damage, destroying the better quality grasses. The turf becomes soft and is pulled up by birds searching for the grubs. Weeds are less attacked and quickly occupy the ground. The larvae feed just below the surface in good weather, moving down to depths of from 4 to 6 inches during adverse conditions. The species is commonly and widely distributed, and the writer has seen very extensive infestations on mountain pastures in Cardiganshire, a great feature of which was the amazing congregation of sea gulls, rooks, jackdaws, starlings and other birds attracted thereto. Curtis (2) mentions that this species was "exceedingly abundant in the autumns of 1839 and 1840 in Hampshire and Gloucestershire, and again in 1844 in various localities."

Previous Experiments on the Control of the Beetle.

H. W. Thompson (3) gives the results of experiments for the control of severe infestations of the Cockchafer, and to a lesser extent the Garden Chafer, in South Wales in 1932 and 1933. Thompson dealt for the most part with land under cultivation, on which he obtained control of the pest by means of applications of naphthalene at the rate of 5-6 cwts. per acre, applied in the early autumn, and also "by summer applications when the material can be worked into the ground, and when there is sufficient rain to wash it well in." He further states "where turf known to be infested cannot for some reason be ploughed up until late autumn, a naphthalene dressing might with advantage be applied in September before the grubs go down for the winter."

The above article was published after the application of the dressings at Yeovil. The Somerset experiment also concerns the application of 2 cwts. per acre to land remaining in old turf.

Hammond (4) in dealing with a species with similar habits (*Phyllophaga anxia* Lec.) in Canada, used sulphur as a deterrent to oviposition for "lawns, golf links, orchards, pastures and other areas which may not be conveniently plowed." The sulphur was "dusted over measured plots in various quantities on May 18th just prior to the first heavy June beetle flight." Check and treated plots were subsequently examined, the soil with the sod covering being carefully dug out to a depth of 10 inches. Any injury to the grass from the sulphur was slight and was quite temporary.

The control plot yielded 89 "white grubs and eggs," whilst 567 lbs. of sulphur per acre gave 85.4% protection (13 grubs and eggs). Increase in the sulphur dressing to 1,474 lbs. per acre gave slightly increased protection, and the writer concludes "that sulphur gives promise of becoming an important deterrent to June beetle oviposition in the case of grass areas," and further gives the opinion that "it is possible that further experimentation will show that commercial control or protection from grubs may be obtained from even smaller quantities of material per acre."

As no British experiments along these lines could be traced, it was decided to carry out a trial, keeping, however, well within the amount used in Canada, since it was felt that the expense incurred must be commensurate with the value of the crop to be of economic value.

Experimental.

Field Trials with Naphthalene, 1933.

On October 9th, 10th, 1933, fields A and B, 20 acres in all, were top dressed with crude naphthalene at the rate of 2 cwts. per acre. The application was made by means of a new (cup) manure distributor. The cost of the naphthalene was £34. The application was followed by cross harrowing and four rollings. There was a considerable rainfall on the night of October 10th, following which numerous dead larvae and earthworms were found on the surface.

At the time of application the number of larvae per square foot was from 20 to 30 on the worst infested areas. On October 23rd when the fields were visited, some living larvae were found at a depth of from one to two inches below the surface, together with dead or moribund specimens, and it was estimated that at least three-fourths of the total were dead or dying. In examining the grasses, it was notable that the stronger types (Cocksfoot, etc.), were comparatively little affected as compared with the finer species.

A second examination was made on 24th November, 1933. There had been very little rain in the interval, but several sharp ground frosts. Eight random samples, each of 1 cubic foot of soil, yielded 6, 4, 2, 1, 8, 6, 2 and 3 living larvae respectively, an average of 4 per square foot of surface. A number of these appeared to be unhealthy. Those still alive had moved to a depth of from 6 to 8 inches below the surface.

A third examination was made on 17th May, 1934, and in field A, 12 random samples of 1 cubic foot of soil in each case yielded 2 pupae in all, at a depth of about 4 inches, and 8 similar samples in field B revealed only 1 pupa at 6 inches below the surface. The soil was very dry below the sod. It was considered that these pupae would hatch in about three weeks time.

During the series of examinations, a few larvae of *Sitona* sp., odd specimens of " Wireworms " and Hepialid larvae, together with an occasional Carabid beetle and earthworm, were found.

Allowing a conservative average of 20 larvae per square foot at the time of dressing in the autumn of 1933, we should have an approximate population of 871,200 per acre, reduced by November

24th to about 174,240 per acre, and to some 6,534 pupae per acre in the following May, a residual population which, it was thought, might suffice to build up once more a sufficient number to cause, in time, further serious injuries.

Field Trials, 1934.

The position in May 1934 being as already described, it was decided to make further observations and trials.

1. To test the relative effect on the behaviour of the beetles as regards oviposition on meadow, as against closely grazed pasture.
    - (*a*) It was therefore decided to continue to mow as previously field A, and this was done on June 20th.
    - (*b*) To graze closely field B (hitherto used for hay), and
    - (*c*) To mow field C, which had been invaded by Chafers in 1933, but had not been treated with naphthalene, when the beetles appeared on the wing.
2. To ascertain whether surface dressings of flowers of sulphur applied after hatching of the beetles would act as a deterrent to oviposition.

Equal areas of fields A and B, separated only by a bank and including in each case some of the worst infested areas of 1933, were surface dressed with flowers of sulphur (see Diagram).

The Effect of Meadow and Pasture Conditions on Oviposition. The fields were examined on June 7th and 8th, 1934 ; the weather was fine and warm, following some rain, with a westerly breeze. Notes were made on the afternoon and evening of the 7th and on the morning of the 8th.

Field A : The hay grass was of fair quality and beetles were numerous and active, feeding for the most part on leaves of Dock (*Rumex crispus*, etc.), flying here and there during sunshine, but settling as soon as clouds appeared. Pairing commenced about 11 a.m., and continued during the warm hours. In the evening the majority settled on the taller weeds and grass, but particularly on the heads of *Heracleum*.

In field C on June 7th, before mowing, conditions were similar to those in field A, but the numbers present were less.

In field B, which was grazed, there were no beetles, except a few along the boundary hedge B-C, and also amongst the foliage of some oak trees in the hedge at the bottom of the fields. On another hay field between field A and the river a few only were present. It will be noted that the majority were congregated about the hay grass on the originally infested slopes, and that the grazed field, with relatively short grass and consequently drier surface, was deserted. Three female beetles, captured on 8th June, 1934, were dissected and yielded 2, 3 and 5 fully developed ova respectively, in each case also there were a number of undeveloped eggs. Three more collected on 21st June were examined and yielded 27, 12 and 9 fully developed ova respectively; again in each case there were a number of undeveloped eggs.

Field Experiments with Sulphur. Four acres of field A (in hay grass) and four of field B (grazed) (see Diagram), were treated with Finest Sublimed English Flowers of Sulphur. The sulphur was applied on 8th June, 1934, by means of a horse-drawn dusting machine (Messrs. Gratton and Fox, Boston, Lincs.) in fine weather. The cost of the sulphur was 19/- per cwt. delivered at Yeovil. The rate of application was 56 lb. per acre except that, owing to some difficulties of adjustment, the lower part of the plot in field A received only about half this amount. At the time of application beetle flight was just commencing, as already described. The amount applied imparted a distinctly yellow hue to the fields and the odour was strong; the tenant stated that this persisted for a very considerable period.

Final Results and Discussion.

A final examination was made on 12th October, 1934, when counts were made in all the fields in the usual manner with the following results:—

Field A (Hay) Control areas—
    An average of 4.3 larvae per square foot.

Field A (Hay) Sulphur dressed—
    (*a*) 25 lbs. per acre, an average of 7.0 per square foot.
    (*b*) 56 lbs. per acre, an average of 0.5 per square foot.

Field B (Grazed) Control area—Nil.

Field B (Grazed) Sulphur areas—
    An average of 1.6 per square foot.

Field C (Hay, mown June 8th)—Nil.

Note: Fields A and B were dressed with naphthalene in 1933.

The results obtained with dressings of crude naphthalene show that relatively light dressings can be used on grassland with good effect on the larvae, if applied at the right time.

The preference shown by the beetles for meadow over closely grazed pasture was marked and this method of control may prove of economic value.

Early mowing at the time of the flight of the beetles also appeared to act as a deterrent to oviposition, and this method of control is worthy of trial as an alternative to pasture conditions.

The results from early mowing and pasture treatments are of special importance since these methods do not involve any expense.

The use of flowers of sulphur as a deterrent to oviposition requires further investigation on more heavily infested land, as it is felt that the experiment did not provide a critical test, since the numbers of beetles were too small, possibly due to the efficiency of the naphthalene treatment in the previous autumn.

Summary and Conclusions.

1. An account is given of a serious infestation of 20 acres of grassland near Yeovil with the larvae of *Phyllopertha horticola L.*

2. Surface dressings of crude naphthalene applied at the rate of 2 cwt. per acre in early October, 1933, effected a marked control of the larvae for that season.

3. Further field trials and observations carried out during 1934 showed that the adult beetles preferred hay grass to land closely grazed; they failed to oviposit on land mown at the commencement of their flight period.

4. A trial using 56 lb. per acre of flowers of sulphur applied as a surface dressing to meadow and pasture grass as a deterrent to oviposition yielded results of an indeterminate character.

ACKNOWLEDGMENTS.

Thanks are due to Mr. J. C. F. Fryer, of the Ministry of Agriculture, and Dr. H. G. H. Kearns, Research Entomologist at Long Ashton, for valued help and advice; to Mr. C. H. Hammond, of the Department of Agriculture of Ottawa, Canada, for details of his experimental work; and to Mr. H. R. James for his wholehearted co-operation and help in connection with the field trials.

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THE EFFECT OF CALCIUM CYANAMIDE AND OF FORMALIN ON PEA "SICKNESS."

PROGRESS REPORT.

By C. L. WALTON, L. OGILVIE and B. O. MULLIGAN.

In the Long Ashton Annual Report for 1933 (6) we described observations and experiments on the disease known as pea "sickness," associated with the eelworm *Heterodera schachtii*, which is widely prevalent in the West of England. In the same Report (5) one of us (Ogilvie) gave the results of the application of formalin solutions to soil affected with the potato strain of the eelworm, prior to planting the tubers.

In 1934 trials were made of the application of calcium cyanamide and of formalin to soil affected with the pea strain of the eelworm in the garden at Berkeley School, Gloucestershire, and at Ston Easton Park, Somerset.

A. Berkeley School.

In this trial the ground was known from observations in previous years to be uniformly infested with the eelworm. There were three adjacent plots, each measuring 52ft. by 8ft.

Treatments.

Plot 1. Calcium cyanamide (10 cwt. per acre or 10.7 lb. per plot) applied on February 20th.

Plot 2. Control. No treatment.

Plot 3. Formalin (1–50 formalin solution, 1 gal. per yard) applied on March 23rd.

The pea seeds were sown in early April, equal amounts to each row. In each plot one row was sown of each of three dwarf varieties, namely Dwarf Defiance, Stratagem and Surprise.

Appearance of Plants.

		Average Height of Plants. Inches.
May 28th.	Plot 1	6—7
„	Plot 2	4
„	Plot 3	6

July 8th.	Observations.	*Av. Hght. of Plants in Inches.* *Dwarf Defiance*	*Stratagem.*	*Surprise.*
Plot 1.	Rows very vigorous and well podded	14	18	16
Plot 2.	All plants notably yellow and much dwarfed, but Surprise apparently healthier than others	10	11	11
Plot 3.	Rows green and well podded ..	15	14	15

Crop Weights.

	Crop Weights in lb. *Dwarf Defiance.*	*Stratagem.*	*Surprise.*
Plot 1	13	7	9
Plot 2	½	nil	3
Plot 3	9	11	9

Observations on Roots, etc.

Eelworm cysts were very numerous on the pea roots from all the plots, but were slightly less on both treated plots. Bacterial nodules were fairly plentiful.

Foot rot was severe on all the plots; of 100 plants examined none were free from foot rot on any of the plots.

B. Ston Easton Park.

Here again the trial was carried out on ground known to be severely infested with *Heterodera schachtii.*

In this case there were four plots, each 5yd. by 4yd. 2ft.

Treatments.

Plot 1.	Calcium cyanamide (10 cwt. per acre or 5.5 lb. per plot) applied on February 21st.
Plot 2.	Formalin (1–50 formalin solution, 1 gallon per yard) applied on March 13th.
Plot 3.	Control. No treatment.
Plot 4.	Formalin (as in Plot 2).

The pea seeds were sown on March 28th, equal amounts to each row, the variety being British Lion (a tall variety).

Appearance of Plants.

May 28th.	*Observations.*	*Average Height of Plants in inches.*
Plot 1.	On this plot the plants were most vigorous ..	3 ft.
Plot 2.	Vigorous	3 ft.
Plot 3.	Least vigorous	2 ft. 9 in.
Plot 4.	Vigorous	3 ft.

Observations on Roots, etc.

As in the first trial eelworm cysts were very numerous on the pea crops from all the plots, but were slightly less on all the treated plots. Bacterial nodules were fairly plentiful.

The amount of foot rot on 100 plants examined is indicated below :—

	No. of plants infected with foot rot.
Plot 1	68
Plot 2	93
Plot 3	100
Plot 4	96

Unfortunately it was impossible to obtain crop weights at this centre.

Discussion.

Our experiments fall into line with those carried out by several workers on the potato strain of *Heterodera schachtii.*

Edwards (2) found that an increased yield of crop of 2 tons per acre followed applications of calcium cyanamide at 10 cwt. per acre to potato sick land.

Miles (4) found that " The application of extra nitrogen, in the form of calcium cyanamide, at from $\frac{3}{4}$ cwt. to 6 cwt. per acre, in 1929, greatly increased the yields of potatoes on potato sick land."

Carroll (1) in the course of pot experiments in Ireland found that " of seven chemicals tested, positive results were obtained only with calcium cyanamide. The plants did not exhibit such severe above-ground symptoms of potato sickness ; the root development was better ; the yield was greater, and there was an appreciable reduction in the number of cysts in the roots."

Hodson (3) also reports in a recent number of the Ministry of Agriculture's " Monthly Summaries of Plant Pests and Diseases " that an application of calcium cyanamide at 6 cwt. per acre to soil affected with potato sickness " was beneficial to the potato crop."

It is pointed out by both Miles and Carroll that the improvement following applications of calcium cyanamide may be entirely due to stimulation by this nitrogenous fertiliser, quite apart from any sterilising or other effect which it may have, although it may be noted that Carroll reports a reduction in the number of cysts.

At the rates employed in our trials, applications of formalin would not be an economic measure. Calcium cyanamide, however, is a chemical which most growers are familiar with, which is of much value as a nitrogenous fertiliser and which may not be over-expensive, the cost of the 10 cwt. per acre dressing being about £4 10s. 0d.

Conclusions.

In both trials the plots treated with calcium cyanamide and with formalin at the rates mentioned produced apparently healthy plants in marked contrast to the control plots.

A slight reduction in the number of cysts on the plants was apparent on the treated plots, and at one centre there appeared to be a reduction of foot rot following the application of calcium cyanamide.

ACKNOWLEDGMENTS.

We wish here to express our indebtedness to Mr. A. S. Morgan, Headmaster of Berkeley School, for facilities and help in carrying out the trial there, to Commander Hippisley and his gardener, Mr. H. Parfitt, for similar facilities at Ston Easton Park, and to Messrs. Shaw Scott & Co., for supplying the calcium cyanamide free of charge.

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INVESTIGATIONS ON CHLOROSIS OF FRUIT TREES.*

V.—THE CONTROL OF LIME-INDUCED CHLOROSIS BY INJECTION OF IRON SALTS.

By T. WALLACE.

In paper No. IV of the present series, (1) experiments were described in which it was shown that a considerable degree of control over lime-induced chlorosis could be obtained by the use of cover crops and permanent grass.

There are many cases, however, in which it is not possible or is undesirable to employ such cultural methods, as for example in gardens where the ground is used for intercrops and for such fruits as plums where a high level of cultivation is desired.

In view of these facts other methods of control have been sought which may be applied in such cases, and of these special attention has been given to a method described by J. P. Bennett, which appeared to be of promise (2).

This method consists of the injection of various amounts of powdered citrate of iron, either ferrous or ferric citrate, into the wood of the trunk or branches of affected trees, the dose being adjusted according to the diameter of the trunk or branch to be treated.

The method is extremely quick and simple to carry out. It only entails the boring of one or more holes in the trunk or branch to be treated, with a brace and bit, introducing the prescribed amount of powdered citrate and plugging the holes with grafting wax. The treatment is best carried out during the dormant season, since the risk of damage from it is then at a minimum.

The doses, number of holes, etc., recommended by Bennett are given in Table I, which is extracted from his original paper.

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* Summary of an article which appeared in the *J. of Pomol. and Hort. Sc.*, Vol. XIII, No. 1, March 1935. Reprinted with the kind permission of the Editors.

TABLE I.

Dosage and Holes for Treating non-Bearing* Chlorotic Trees by the Dry-Salt Method. (After Bennett.)

Tree Diameter. Inches.	Holes.			Amount of Salt.	
	Number.	Diameter. Inches.	Depth. Inches.	Per Hole. Ounces.	Per Tree. Ounces.
1	1	$\frac{1}{4}$	$\frac{5}{8}$	0.01	0.01
$1\frac{1}{2}$	1	$\frac{1}{4}$	1	0.02	0.02
2	1	$\frac{7}{16}$	$1\frac{1}{4}$	0.05	0.05
3	3	$\frac{7}{16}$	$1\frac{1}{4}$	0.03+	0.10
4	4	$\frac{7}{16}$	$1\frac{1}{2}$	0.05	0.20
5	5	$\frac{7}{16}$	$1\frac{3}{4}$	0.06	0.30
6	6	$\frac{7}{16}$	2	0.08+	0.50
7	7	$\frac{7}{16}$	2	0.08+	0.60
8	8	$\frac{7}{16}$	$2\frac{1}{2}$	0.09	0.70
9	9	$\frac{7}{16}$	$2\frac{1}{2}$	0.09	0.80
10	10	$\frac{7}{16}$	$2\frac{1}{2}$	0.10	1.00
15	15	$\frac{7}{16}$	3	0.10	1.50
20	20	$\frac{7}{16}$	3	0.10	2.00

* The dosage is reduced to one-half or two-thirds of that recommended in the Table for Bearing Trees if injury to blossom is feared.

Bennett points out in his paper that the dosage and technique adopted have been developed mainly from experience with pear trees and adjustments may be required when dealing with other kinds. He states that " about 75,000 pear trees have been successfully treated by the method, mostly by growers themselves."

The improvement effected by the treatment is not to be regarded as permanent but usually lasts for about three years when the process may require repeating.

The experiments described in the present paper were carried out at four centres on apples, plums and pears, the treated trees in each case being severely affected by chlorosis and in very poor condition. The injections were made in March, 1933, immediately prior to buds bursting, and records on the condition of the trees are available for the seasons 1932, 1933 and 1934.

The results obtained are similar to those described by Bennett, and indicate that the method may be of considerable commercial value.

Experimental.

The Centres.

Centre A. Two experiments were carried out at this centre :—

(*a*) On a block of 40 apple trees, variety chiefly James Grieve with a few Worcester Pearmain. The trees were in two rows of 20, planted at 15ft. square, about 10 years old, and had been trained originally as espaliers. Practically every tree was more or less chlorotic, often severely, and showing die-back.

For the purpose of the experiment, an area containing twelve trees in each row was allowed to become overgrown with grass and weeds and the remainder kept under cultivation. The trees in the cultivated group, with the exception of Nos. 13 and 33, which were treated as buffers between the two plots, were given the injection treatment. The object of the weed treatment was to compare the effects of this with the injection treatment.

(*b*) Eight pear trees, variety Conference, about 5 years old, trained as cordons and growing in one row of a block, planted 30ins. apart in the row and rows 5ft. apart, were treated. They were all very poor trees, and severely chlorotic.

The area at Centre A is part of a commercial fruit plantation. The site is a gentle to medium slope to the south. The soil is mainly derived from Keuper Marl with a slight admixture of Bunter Sand and Gravel. The surface soil contains about 1 per cent. $CaCO_3$, but there are bands of soft calcareous rock in the subsoil layers.

Centre B. Seventeen plum trees, growing in a commercial plantation, were treated. Fifteen were of the variety Pershore Egg and two of the variety Victoria. The trees are very old, probably over 50 years, and were generally large specimens but showed much chlorosis, dying back of large branches and the wood of both trunks and branches was often rotten and many trunks were hollow.

The site is slightly elevated and level, the soil being derived from a local Boulder Clay, which is mainly a mixture of Keuper Marl and Lower Lias Clay and is highly calcareous.

Centre C. The plot is located in a garden and contains nine bush apple trees, varieties Newton Wonder and Gascoigne's Scarlet, between 20 and 30 years of age. The trees are planted in 3 rows, each containing 3 trees, and had previously made fairly strong growth, although for many years showing a fair amount of chlorosis, and this was generally severe just prior to the treatment, shoot growth being greatly restricted.

The site is rather low lying and level, and the soil derived from a highly calcareous Lower Lias Clay. The plot is highly cultivated for the production of bulbs.

Centre D. The trees at this centre are all bush apple trees and occur in three blocks of different ages in a garden.

(*a*) *Block I.* The block contains nine trees which have been under observation for several years. They are about 20 years old and previous to 1928 were growing under cultivated conditions, when chlorosis was very severe. Since then they have been under grass, treated like a lawn, and most of the trees have grown well, but two have continued to grow very badly, although only one of these has shown appreciable chlorosis. These two trees were selected for treatment.

(*b*) *Block II.* These trees are about 10 years old and for the greater part of the time have been grown under conditions of a grass lawn. Two trees of the eight which have not grown well and show chlorosis were treated.

(*c*) *Block III.* These trees form a block of miscellaneous varieties, about 5 years planted and growing under conditions as in Block II. Six trees showing varying degrees of chlorosis and poor growth were selected.

The site of this centre is somewhat elevated, but practically level, the soil being derived from Dolomitic Conglomerate, very shallow and containing a high proportion of carbonates.

Method of Treatment.

The methods used in making the injections were similar to those described by Bennett, slight modifications being made to suit the circumstances. Ferric citrate was used. This was purchased as "scales" and these finely ground to a powder in a laboratory mortar. For convenience in measuring the doses in the field, a series of holes of appropriate sizes were made in the ends of corks so as to hold the amounts likely to be used when the holes were filled with powder flush to the surfaces with gentle tapping.

The tree holes were bored in trunks and branches by means of a brace and bit, bits ½in. and ⅜in. respectively being used for larger and smaller limbs. Where more than one hole was bored in any trunk or branch, these were made at slightly different levels so that if damage occurred to the wood the treated limb would not be ringed. The bore holes always pointed slightly downwards so that the powder could be easily placed in the bottoms.

To introduce the powder into the holes, it was poured on to a piece of smooth paper and this tilted into a glass adaptor tube with slightly narrowed end which was fitted into the hole so as to touch the bottom. The powder was gently tapped down the tube, the last portions being pushed out into the hole with a camel hair brush and a piece of copper wire. The powder was finally pressed with a flat-ended glass rod and a small cork inserted in the hole.

As the treatments were carried out rather late in the dormant season, from March 13th-22nd, and the buds were practically at the bursting stage and some even burst, the amounts of powder given were generally only about half to three-quarters of those recommended by Bennett, and in certain cases no doubt could be increased with advantage.

The operations were found easy to perform and given dry, still weather could be carried out easily by unskilled labour.

Results.

Records were obtained for individual trees at the four centres, relating to shoot growth and chlorosis for the seasons 1932, 1933 and 1934, and also to cropping for 1934. Since the injection treatments were given in March, 1933, the growth and chlorosis records thus refer to the season immediately prior to the treatment and to two others immediately following. The crop records for 1934 were obtained since the crops in that season were medium to heavy at all centres and these might have been expected to place a heavy strain upon trees not in good condition.

In order to express the results on a numerical basis, the records for shoot growth and chlorosis, which were expressed each year as Good, Medium, Bad, etc., have been treated as follows :—

Shoot growth : Very good = 4 ; Good = 3 ; Fairly good = $2\frac{1}{2}$; Medium = 2 ; Bad = 1.

Chlorosis : Nil = 0 ; Trace = $\frac{1}{2}$; Very slight = 1 ; Slight = 2 ; Medium = 3 ; Bad = 4.

The crop records for 1934 have not been treated in this way, but may be regarded generally as medium to heavy.

The results for shoot growth and chlorosis are summarised in Table II.

TABLE II.

Summary of Records for Shoot Growth and Chlorosis.
Average Markings per Tree.

Plot.	Shoot Growth.			Chlorosis.		
	1932	1933	1934	1932	1933	1934
Centre A.						
Plot a.—Apples.						
Grass Plot—24 trees ..	1¾	2¼	3¼	2¾	1	1
Cultivated Plot. Injected Trees—14 trees	2¼	4	3¾	3¼	½	1
Plot b.—Pears—8 Trees	1½	3	3¼	4	½	¼
Centre B—Plums.						
17 Trees	—	2¾	3¼	3½	¾	½
Centre C—Apples.						
9 Trees	—	4	4	3¼	¾	1¼
Centre D—Apples.						
Block 1—2 Trees* ..	1	3	3	3½	0	0
Block 2—2 Trees ..	1	2½	3½	3½	0	0
Block 3—5 Trees ..	2	4	4	2½	0	0

* 1 Tree died, thus records only for one tree.

Discussion.

The results as summarised in Table II show that the injection treatment has greatly improved the trees in all the experiments, and in fact in all cases it has converted typical failures due to chlorosis into normal healthy specimens. The main point of interest now lies in the time over which the treatments will remain effective, there being indications in two cases, Centre A, Plot *a*—Apples, and Centre C—Apples, that the chlorotic conditions are returning. In this connexion it should be noted that the doses applied have only been from one-half to slightly over this amount of those recommended by Bennett, and since it appears that the doses could be safely increased, in all probability more lasting effects can be obtained.

A further point has emerged from the observations which is that special attention must be paid to the positions at which the injections are made. In these experiments, in most of the cases where chlorosis was recorded as "Trace" or "Slight" after injection treatment, the symptoms were confined to branches which had obviously been "missed" by the treatment. Improvement in this respect would undoubtedly be achieved by placing the holes in positions for particular purposes as suggested by Roach (3). This point is being tested in further experiments.

The main points in connexion with the individual centres are as follows :—

Centre A—Plot a. Apples. Both the grass and injection treatments were effective in the season of the treatment, 1933, the results from the latter being especially excellent. In 1934, there was some return of the chlorosis on the injected trees, but those under grass remained as in 1933. In the grassed area, it should be noted that the grass cover has been very poor in both seasons, especially for trees 9—12 and 29—32. Shoot growth continued to improve on the grassed trees in 1934.

Centre A—Plot b. Pears. The results here have been excellent, but in 1934 cultivation was neglected and the plot was very weedy, which condition may have assisted in checking chlorosis.

Centre B. In spite of the fact that these trees are very old and much of the heart wood rotten, the effects produced have been very marked and the trees appear to have become rejuvenated. The only chlorosis present is on " missed " branches, and in 1934 both shoot growth and crop were excellent.

Centre C. The effects observed in 1933 were excellent, the treatment resulting in very vigorous shoot growth, which was maintained in 1934, and the disappearance of chlorosis excepting from shoots which were probably " missed."

There was a very definite return of the chlorotic conditions in 1934 on young growths and maybe increased doses will be required at this centre.

Centre D. Apart from the death of one tree in 1933, immediately following the treatment, the results have been excellent. Chlorosis, so far, has been entirely cured and the trees are healthy and vigorous. The killed tree, it should be noted, has been in a very weak condition for many years, and in any case was quite useless. It should be observed that at this centre all the trees are already under " grass lawn " conditions, which had already greatly improved the conditions of most of the trees on the plot, but had failed to produce satisfactory results in the treated specimens. It is suggested that a combination of injection and covercrop treatments may provide an excellent solution of the trouble in many cases where covercrops are possible.

The results obtained in these experiments indicate that the method of dry salt injection is of considerable value as a means of controlling lime-induced chlorosis and should be useful in commercial plantations.

ACKNOWLEDGMENTS.

Mr. B. O. Mulligan has assisted with the injections and the records, and Dr. D. A. Osmond with the records.

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SPOTTED WILT OF TOMATOES AND ITS CONTROL.

By L. OGILVIE.

In the 1932 Report of this Institute (10) the writer drew attention to the occurrence of Spotted Wilt of Tomatoes in the Bristol Province and pointed out the seriousness of the disease to tomato growers and nurserymen. Since then it has become considerably more common and most growers are now familiar with the symptoms on tomatoes, namely, bronzing of the young leaves in irregular spots or circles, accompanied by almost complete cessation of growth. More information is now available regarding the host range of the virus, and it has been shown that this now extends into 14 different families and includes a large number of plants commonly grown in mixed glasshouses, several of which often accompany tomatoes. Moreover, evidence regarding the methods of transmission of the virus shows that it is not commonly transmitted by seed.

The present article summarises recent work on the host range of the virus, indicating the dangers of infection to tomatoes which arise from growing other crops in tomato houses, and shows how satisfactory control of the trouble may be attained by roguing of diseased plants accompanied by routine fumigation to destroy insect vectors.

Host Plants commonly found in Tomato Houses.

It has been found that the disease is uncommon in houses which are entirely given over to tomatoes. It was therefore regarded as most important to obtain information on the possible infection of plants commonly grown in association with tomatoes. One of the commonest of these is the Calla or Arum Lily, *Richardia* (*Calla*) *africana*, and on several occasions from April, 1933, onwards, severe outbreaks of spotted wilt on tomatoes were discovered in greenhouses where there was also a marked spotting of the leaves, stems and flowers of Callas (Plate I). This spotting seemed suspicious since it took the form of concentric rings and necrotic markings reminiscent of spotted wilt symptoms on tomato leaves. Specimens were submitted to Dr. Kenneth Smith, who finally

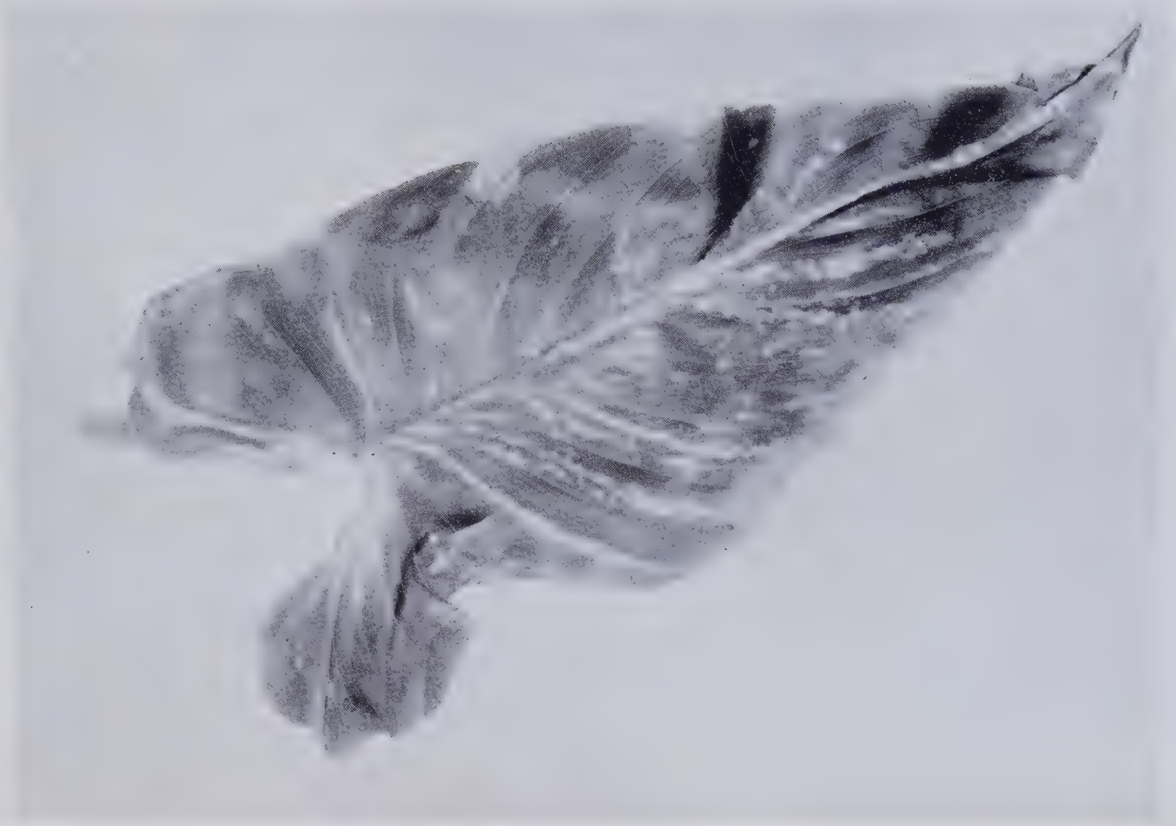

PLATE I.

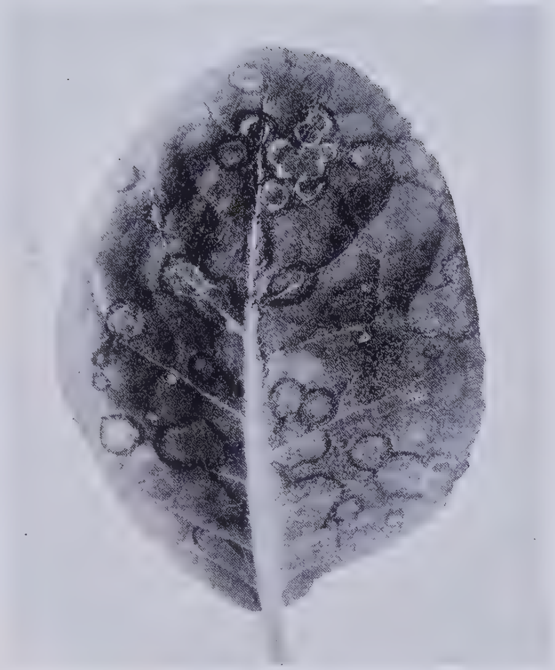

PLATE II. FIG. 1.

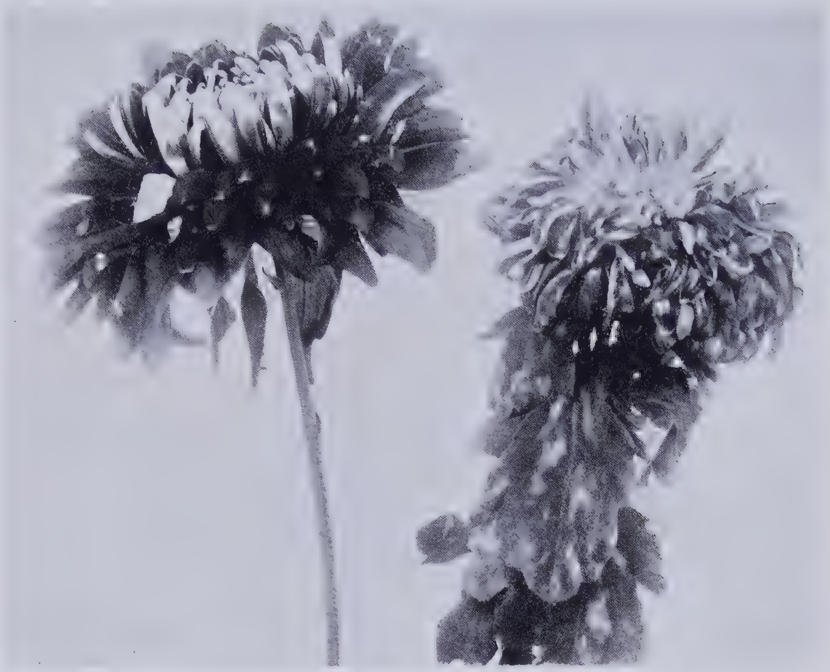

PLATE II. FIG. 2.

confirmed their infection with spotted wilt in April, 1934. This was the first monocotyledonous host recorded. Infection of Callas has also been reported from California (5, 6). As has been pointed out by Ainsworth (3), the infection of Callas is most important, since the flowers are a favourite breeding place for *Thrips tabaci*, the insect which transmits the disease in England.

There has been some controversy regarding the infection of chrysanthemums. The writer has often noticed plants with a suggestive mottling of the leaves accompanied by abnormal streaking of the flowers (Plate II, Fig. 2), and has submitted material to Dr. Smith from time to time, but he obtained no positive results. On the other hand he regarded it as " highly probable that the chrysanthemum is susceptible to spotted wilt."* Ainsworth, again, stated in the Cheshunt Report for 1932 (1) that in December, presumably of that year, " chrysanthemums, showing brown areas on the leaves, small lesions on the stems, and a withering of the flowers, were received from a grower who had had a serious attack of spotted wilt on tomatoes in the spring." Ainsworth succeeded in isolating the virus of spotted wilt from these plants. All attempts, however, to inoculate healthy chrysanthemums with the disease in this country seem to have failed, but in California (5) and Australia (4) it has been transmitted from tomato to chrysanthemum by rubbing, and in the latter country the virus has been returned subsequently to tomato.

The infection of Callas and Chrysanthemums is of the greatest importance since both these plants are often present in the houses when tomato seedlings are being raised, and, being perennials, they carry over the disease from year to year.

Infection of lettuces, another common tomato-house crop, has been recorded from California (5), but apparently not from England.

Other Host Plants.

The names of host plants recorded from England (1, 2, 3, 7, 8, 9, 10, 11, 12) are given in Table I. Many of these have been observed to be infected in the Bristol Province.

In California (5, 6) the disease has recently been recorded from the plants listed in Table II.

In Australia (4) also many of the hosts recorded in Table I have been infected, and also *Lycium ferocissimum*, *Physalis peruviana* and *Salpiglossis* (all *Solanaceae*). The Iceland Poppy (*Papaver nudicaule*) is very commonly infected in gardens.

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*Private communication.

Many of the host plants recorded are commonly found in mixed glasshouses in England. The symptoms vary greatly from plant to plant, but any mottling, "clearing of the veins," bronzing, or ring spots occurring on these plants should be regarded with suspicion.

The disease occurs out of doors in California and Australia, and there does not seem to be any reason why it should not prove troublesome outside in this country too, as *Thrips tabaci* is prevalent during the summer. Numerous infected China Asters were found in outside plantings in Somerset in 1934, but as these had been originally raised indoors in infected greenhouses it was impossible to say whether spread had taken place outside.

TABLE I.

Plants Affected with Spotted Wilt in England.

Family.	
Amaryllidaceae	*Amaryllis* (*Hippeastrum*).
Araceae	Calla (Arum) Lily. (*Richardia* (*Calla*) *africana*).
Papaveraceae	Iceland Poppy (*Papaver nudicaule*) (9).
Tropaeolaceae	Nasturtium (*Tropaeolum majus*), especially Bodger's double forms.
Leguminosae	Lupin (? *Lupinus polyphyllus*). Broad Bean (*Vicia Faba*).
Onagraceae	Fuchsia (9).
Compositae	Chrysanthemum (1, 9), Cineraria, Dahlia, Zinnia, China Aster (*Callistephus chinensis*).
Campanulaceae	? Foxglove (8, 9), *Campanula pyramidalis*, *Lobelia* (? *cardinalis*) (8), *Trachelium caeruleum*.
Primulaceae	*Primula malacoides*, *P. sinensis*.
Solanaceae	Many species of *Nicotiana* and *Solanum*, including Tobacco, Tomato, Potato, Egg-plant (*Solanum Melongena*), Winter Cherry (*S. capsicastrum*), Black Nightshade (*S. nigrum*), Woody Nightshade (*S. dulcamara*), and *S. aculeatissimum*. Belladonna (*Atropa Belladonna*), Cape Gooseberry (*Physalis* sp.) (8), Chilli (*Capsicum annum*), Henbane (*Hyoscyamus niger*), Thorn Apple (*Datura Stramonium*), Gloxinia (6) (Plate II, Fig. 1), Petunia, Schizanthus, *Browallia speciosa major*, *Streptosolen Jamesonii*.
Plantaginaceae	Great Plantain (*Plantago major*).
Begoniaceae	Begonia.
Scrophulariaceae	Antirrhinum (9), Calceolaria (9), Pentstemon (9).
Urticaceae	? Nettle (*Urtica dioica*) (11).

TABLE II.

PLANTS AFFECTED WITH SPOTTED WILT IN CALIFORNIA (5, 6).

FAMILY.	
Amaryllidaceae	*Amaryllis* sp.
Araceae	Calla (*Richardia africana*).
Ranunculaceae	Delphinium.
Papaveraceae	Poppy.
Cruciferae	Cauliflower, *Cheiranthus*.
Tropaeolaceae	Nasturtium (*Tropaeolum majus*).
Leguminosae	Lupin, Broad Bean.
Onagraceae	Godetia.
Umbelliferae	Celery.
Compositae	Chrysanthemum, Cineraria, Dahlia, Zinnia, China Aster, Lettuce, Gaillardia, *Emilia*, *Layia*.
Campanulaceae	*Campanula*.
Primulaceae	*Primula*.
Martyniaceae	*Martynia*.
Solanaceae	Many species of *Nicotiana* and *Solanum*, including Tobacco, Tomato, Potato, Egg-plant, Pepper, Physalis, Datura, Gloxinia, Petunia, Schizanthus, Salpiglossis, *Nicandra*.
Scrophulariaceae	Calceolaria, Pentstemon.
Verbenaceae	Verbena.
Labiatae	Salvia.
Begoniaceae	Begonia.
Urticaceae	Nettle.

Possible Seed Transmission.

Many workers have grown seeds from infected tomato plants under controlled conditions but in no case has seed transmission been proved. In 1934, 120 seedlings were raised in insect free conditions from seed gathered from spotted wilt plants, and grown till they were 6in. high. All the plants remained free from the disease.

Control Measures.

Experience in the Bristol Province has shown that spotted wilt can be controlled in a house entirely given over to tomatoes if frequent roguing is carried out and thrips are kept down by nicotine fumigation or spraying. In houses where infected Callas were also grown removal of the diseased Callas and subsequent routine fumigation also controlled the diease completely. It is advisable for the worker to wash his hands with soap and water after touching the diseased plants, since it is probable that the virus is also spread in this way to some slight extent.

Houses with a very mixed population of plants present a difficult problem and growers are advised to keep tomatoes isolated as far as possible. On the other hand, it is not difficult for the observant grower to become familiar with the symptoms and to be able to rogue out infected ornamentals successfully.

Growers should also consult the valuable leaflet published by the Ministry of Agriculture and Fisheries :—" Spotted Wilt of the Tomato," Advisory Leaflet, No. 238. The leaflet may be obtained free of charge from the Ministry or from this Institute.

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PLATE I.

Fig. 1. Spotted Wilt on Calla.

PLATE II.

Fig. 1. Spotted Wilt on Gloxinia.

Fig. 2. Suspected Spotted Wilt on Chrysanthemum. Normal Flower on left.

PROGRESS REPORT ON VEGETABLE DISEASES—VI.

By L. OGILVIE, B. O. MULLIGAN, and P. W. BRIAN.

INTRODUCTION.

The following report, which deals with investigations on Vegetable Diseases in the Bristol Province carried out during the season 1933-34, is a continuation of those previously published in the Annual Reports of this Institute.

Short popular articles on these investigations have continued to appear in the Worcestershire Agricultural Quarterly Bulletin (8), and a series of articles of interest to Gloucestershire growers has been commenced in the corresponding Gloucestershire bulletin. A lecture entitled "Vegetable Diseases—Recent Work at Long Ashton," was delivered by two of us at the Reading University, Horticultural Department "Revision Course," on September 11th. A summary of the lecture will be published in "Scientific Horticulture," Vcl III, 1935.

Dr. C. L. Walton, the Advisory Entomologist, has co-operated with us in further work on the pea strain of *Heterodera schachtii* and its relation to pea "sickness." Observations on this disease are published in a separate paper.

ASPARAGUS DISEASES.

Asparagus Rust.

Although a small patch of asparagus affected with rust (*Puccinia Asparagi*) was discovered in the Evesham area in 1933, the district was entirely free from rust in 1934, despite extensive outbreaks in the Eastern Counties.

Violet Root Rot (*Rhizoctonia Crocorum*).

Although previous to 1934 the Violet Root Rot fungus had been found by us on dock, bindweed, and dandelion in addition to asparagus, there was no evidence that any other crop plants were affected in the Evesham district, and it was considered possible that the asparagus fungus might be a specialised strain. This was the opinion put forward by Eriksson (4) in Sweden, who went so far as to retain the name *Rhizoctonia Asparagi.* Fuckel for it.

In England there have been records of the occurrence of the fungus on many root crops, and it was important to find out whether such crops could be grown on infected land. Through the kindness of Mr. A. G. Kerr, several trial plots were laid down on severely infected ground in the middle of an asparagus field at Badsey. Seeds of the following were sown early in April, 1934 : carrots, garden beets, sugar beets, mangolds, parsnips, turnips, potatoes, dwarf beans and red clover. No infection was observed on June 27th, but when the plants were examined on August 3rd it was found that several of the mangolds and parsnips were slightly affected and many of the carrots severely affected.

On September 7th, many of the sugar beets were found to be attacked, but many were clean. Many of the mangolds, carrots, and beets were badly affected. When the potatoes were dug in October, several tubers were found to be covered with mycelium of the fungus.

The trial showed therefore that the form of *Rhizoctonia Crocorum* occurring on asparagus in the Evesham area can attack carrots, garden beets, sugar beets, mangolds, parsnips and potatoes. Under the conditions of the trial, red clover, dwarf beans and turnips were not affected, although several hundred plants of each were grown. In the case of the affected plants a premature yellowing of the tops was observed and copious mycelium was found on the roots.

The injury to the carrots was especially severe, the roots being covered with a heavy mycelial growth and eventually breaking down in a soft rot. It was also noticed in the case of this crop that the disease developed more quickly than in the case of the others.

The infection of carrots was noticed by Barker and Gimingham in this area in 1916 and 1917 (2, 3) when they carried out fungicidal trials. This vegetable is not now very frequently grown in the Evesham area and the disease has not been previously observed on carrots by us.

The above trials indicate that the fungus on asparagus is by no means a specialised strain. Although we have frequently observed peas and Brussels sprouts growing on infected ground these have never been found to be affected. Any of the susceptible vegetables indicated in the trials should be avoided in planting infected areas.

TABLE I.

FUSARIUM FOOT ROT OF DWARF BEANS.

VARIETY RESISTANCE TRIAL, BADSEY FIELDS, NR. EVESHAM, 1934.

Notes on July 16th, 1934.

Variety.	*Date of Sowing.*	*Average Height in inches.*	*Percentage of Plants showing Severe Symptoms.*	*Remarks.*	*Crop weight in lb. of two rows.*
Ne Plus Ultra	20.4.34	4	66	Many plants much dwarfed, chlorotic, lower leaves shrivelled. Bases severely affected but many plants fairly healthy and green.	2
Canadian Express	do.	5	69	Severely affected. Much dwarfed. Lower leaves chlorotic.	2½
Williams's "Earliest of All"	do.	4	50	Greener than foregoing, but also severely affected. Much dwarfed.	1¾
Black Wonder	do.	4	82	Severely affected. Fairly green, but much dwarfed.	2
Early Saxony	do.	4	83	Severely affected. Plants dwarfed. Lower leaves chlorotic.	1½
Early Warwick	do.	5	65	Most plants severely affected. Several plants healthy.	2
Fin de Linas	3.5.34	5	70	Pods with brown streaks. Badly affected. Leaves green but plants much dwarfed.	1½
Goliath	do.	5	83	Severely attacked. Much yellowed and shrivelled.	1
Flageolet Victoria	do.	6	57	Many plants severely affected but many healthy. Apparently tends to throw more stem roots.	1½
Flageolet St. Andrew	do.	6½	41	Fairly good growth. Plants green. More stem roots.	4¼
Best of All	do.	5	65	Severely affected, dwarfed and chlorotic.	1½
Black Prince	do.	5	85	Severely affected. Leaves darker green.	4
Masterpiece	do.	5	71	Severely affected. Some plants quite good.	4¾
Leicester Wonder	do.	5	72	Severely affected. Much dwarfed. Not very chlorotic	1¾
Unrivalled	do.	5	95	Severely affected. Dwarfed and chlorotic.	1½
Satisfaction	do.	4½	93	do.	2
Canadian Wonder	do.	6	80	Severely affected. But many fairly good plants with development of stem roots.	2¾
The Wonder	do.	6	89	Severely affected. Dwarfed and chlorotic.	4
Abundant	do.	6	94	do.	1
Early Prolific	26.5.34	—	—	Sown too late to be comparable with others. Affected at stem bases.	—
Superlative	3.5.34	4½	94	Severely affected. Dwarfed and chlorotic.	2
Incomparable B.	do.	4	96	Severely affected. Not so chlorotic.	2¾
Magpie	do.	4½	89	do.	1¼

DISEASES OF DWARF (FRENCH) BEANS.

Foot Rot.

Fusaria Implicated. Further pot experiments were carried out with nine *Fusaria* isolated from " foot rot " plants, in comparison with a culture of *F. Solani* var. *Martii* (App. et Wr.) Wr. isolated in 1932. Although several of the nine *Fusaria* were slightly pathogenic, none produced so severe and consistent results as *F. Solani* var. *Martii.*

Resistance Trials. In 1933 it was observed that dwarf beans interplanted with asparagus on a piece of ground at Badsey Fields were severely infected with foot rot. Through the kindness of Mr. Austin Jones it was possible to lay down a trial of over 20 varieties to test their susceptibility. The attached table indicates the results. The average number of plants of each variety was 200.

One striking feature about the trial was the fact that in several varieties there was a very marked difference in susceptibility among individual plants, some seedlings of slightly different growth habits being little affected by the disease. The difference in height between normally affected plants and these seedlings was remarkable. Thus resistant Black Prince seedlings were 9ins. high while normal plants were 4ins. high. Seeds were kept from many of these and will be utilised next year. The crop weights were brought up by these seedlings in the case of the varieties Masterpiece, Canadian Wonder and Incomparable.

The most outstanding variety was Flageolet St. Andrew, which has been found in our previous trials to resist the disease satisfactorily. In this variety the bases of the stems were affected with foot rot, the lower roots being killed off, but there was a marked development of adventitious roots above the lesions, and this was also the case in the seedlings referred to above.

DISEASES OF RUNNER BEANS.

Wilt.

Fungi implicated. Inoculation experiments have been carried out with numerous *Fusaria* isolated from wilted beans, but only one species appears to be pathogenic. Cultural studies have been carried out on this organism.

DISEASES OF BRASSICAE.

Finger-and-Toe.

Control Treatments. Through the kind co-operation of Messrs. Collett and Hubbard a trial was laid down in 1932 at Mickleton, Gloucestershire, to test the value of quicklime, calcium hydrate and calcium cyanamide in the control of finger-and-toe on Brussels Sprouts under local conditions.

The soil is a Honeybourne loam of pH about 5.2 and the plot had given consistently diseased crops for several years previously. Each plot is 1/7th acre in area, and each material tested is applied to two plots at different rates as shown in Table II.

The rates of the dressings of quicklime and hydrated lime given are heavy, while the amounts of calcium cyanamide used are fairly normal dressings of this chemical for Brassicae on horticultural holdings.

The applications of lime were made in January of each year, immediately after ploughing, while the cyanamide was applied in April. There was an average of 60 plants in each plot each year.

The results to date are summarised in Table II.

TABLE II.

CONTROL OF FINGER-AND-TOE BY LIMING, ETC.

BRUSSELS SPROUTS TRIAL PLOTS AT MICKLETON, GLOS. 1932-34.

Plot.	*Treatment.*	*Rate of Application per acre.*	*Averages of Pairs of Plots. Per cent. Diseased Plants.* 1932	1933	1934
1	Calcium cyanamide	(1) 3 cwt. 1932, '33: 4 cwt. 1934 (2) 4 cwt. 1932, '33: 8 cwt. 1934	89	54	81
2	Ground burnt lime	(1) 3 tons 1932, '33, '34 (2) 4 tons 1932, '33, '34	90	64	53
3	Hydrated lime	(1) 3 tons 1932, '33, '34 (2) 4 tons 1932, '33, '34	89	46	53
4	Control		93	64	89

It will be seen that in the third year a considerable reduction in disease percentage has taken place from both the ground burnt lime and hydrated lime treatments, while little reduction is evident from the use of cyanamide. Records will be continued on the plots in future to follow the effects of the lime dressings already applied and to determine the effects of continuous routine dressings of cyanamide.

Mosaic.

A mosaic disease of cabbages and other Brassicae is under observation. It was very common in plantings of cabbages at Bristol in 1934 and is characterised by a very marked clearing and necrosis of the veins, accompanied by yellowing and dwarfing of the plants.

DISEASES OF CELERY.

Soft Rot.

During 1934 soft rot of celery was fairly widespread and destructive throughout the Province, and at present a comparative study is being made of bacteria isolated from this and other soft rots. It seems probable that the bacteria associated with the celery soft rot in all the cases concerned are of the species *Bacillus carotovorus* and that the disease is similar to that which has been described by Wormald (14).

Soft rots caused by *B. carotovorus* are usually associated with injury by insects, etc., and the cases under observation have been especially interesting in this respect.

(1) *Carrot fly injury.* Much soft rot occurred early in January, 1934, in a market garden in Bristol, where the celery had been heavily earthed up. The garden is one in which carrot fly injury is common. Naphthalene had been applied during June and July when the celery was put out but following a warm summer a second carrot fly attack had apparently taken place in October. Much soft rot of the tips followed, the rot spreading from the tunnels of the carrot fly larvae. (Plate I, Fig. 2.)

(2) *Slug injury.* Soft rot again developed in the same garden during December and in this case was associated with slug injury.

(3) *Drosophilid injury.* Soft rot was prevalent in celery plantings at Frenchay early in October, 1934, and was found especially on pink varieties. In this case the injury usually commenced at the tips of the innermost blanched leaves and dipterous larvae were often found both on these tips and in the rotted petioles to which the rot had spread. (Plate I, Fig. 1.) Eggs were found on the leaf tips and early stages of the larvae were surrounded by rotten areas. These larvae were bred out and were identified by Dr. Harry Britten as *Scaptomyza graminum* Fall. Dr. Britten has stated that this is a common Drosophilid, usually found about rotting vegetable matter, and that he has had it from celery previously.

It is of interest that spread of this disease had taken place during abnormally dry and warm weather, whereas experience with other

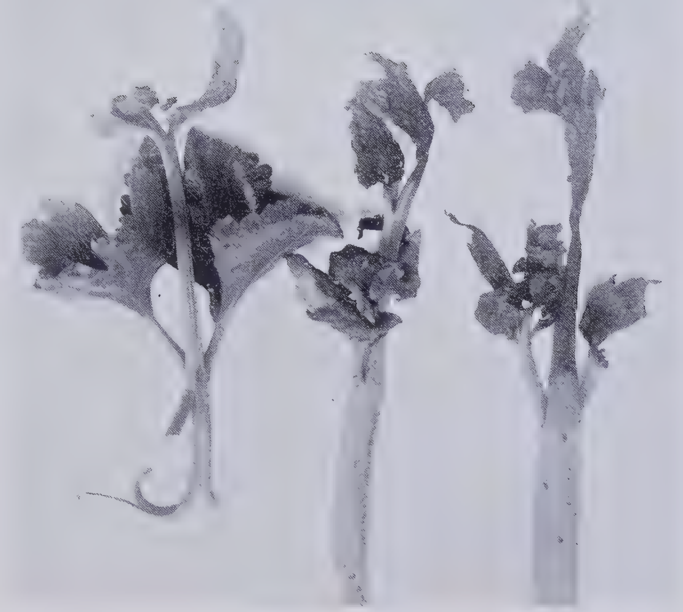

PLATE I. FIG 1.

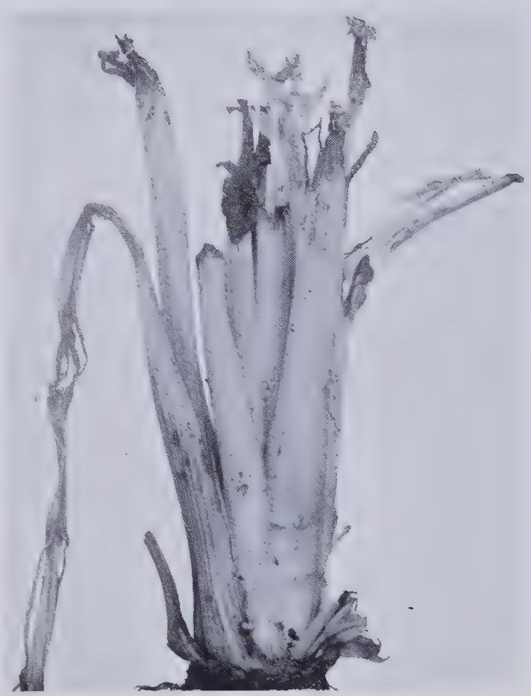

PLATE I. FIG 2

DISEASES OF LEEKS.

White Tip (*Phytophthora Porri*).

Further work was done on the selection of strains resistant to this disease.

DISEASES OF LETTUCES.

Botrytis Disease.

A dying off of winter lettuces growing in the open has been under observation since 1928. The disease is due as mentioned in our 1932 report, to certain species of *Botrytis*, which are at present being critically investigated.

This disease of lettuces and other symptoms caused by *Botrytis* attack have also been described by Abdel-Salem (1) and White (13) in recent papers.

Through the valuable co-operation of Messrs. J. & J. Brown, of Frenchay, it was possible during the winter of 1933-34 to make further observations on the relative resistance of many varieties of lettuce.

Table III has been supplied by Messrs. Brown and indicates the percentages of fourteen varieties which survived the winter. As already indicated it is considered that most of the " winter killing " of winter lettuces in this locality is due to *Botrytis.*

It will be seen that Lees Immense (various strains) Arctic (Arctic King), Imperial and Yate's Winter White, all proved satisfactory winter varieties in this respect, all having a survival of over 70%. This agrees with experience in the previous year (see 1933 Report).

The measurements of the average diameters of the plants on April 11th give some indication of the earliness of the varieties. All the varieties mentioned above had a good appearance from the market point of view on this date.

The classifications of lettuces given in the Ministry of Agriculture's Bulletin No. 55 (Salad Crops) (7) and in the Report of the Royal Horticultural Society trials at Wisley in 1922-23 (9) indicate that Lees Immense and Yate's Winter White are probably both forms of Hammersmith. Arctic and Arctic King are practically synonymous. Imperial is a selection of Green Winter Passion.

Ring Spot (" Rust ") *(Marssonina panattoniana).*

Application of Copper to Soil, etc. A piece of ground at Cheltenham, which had previously borne lettuce plants badly affected

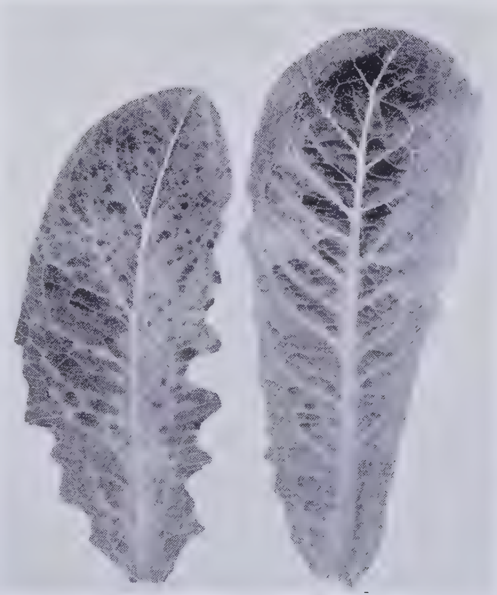

PLATE II. FIG. 1.

PLATE II. FIG 2.

with *Marssonina*, was dusted with copper lime dust at the rate of about 40 lbs. per acre over half its area on November 8th, 1933, and was planted with lettuces soon after. On March 28th, 1934, it was observed that the plants on the dusted plot looked bronzed and stunted, while the controls were green and were growing more strongly. On April 17th, the plants on the treated plot were growing away slightly and had lost their bronzed appearance, but were still very poor and much smaller than the controls. *Marssonina* was very prevalent on both treated and untreated plots. On May 7th, infection was very severe, practically 100% on both plots.

Plants dipped in Bordeaux mixture previous to planting out were similarly checked, and no apparent control was obtained.

Variety Trial. In a trial at Birlingham, Pershore, the three varieties Spring Beauty, Arctic and Imperial were employed. Imperial became very severely infected with *Marssonina*, having apparently been infected in the seed bed ; Arctic was moderately infected, while Spring Beauty was fairly free from disease. The disease was prevalent elsewhere on Imperial, and this variety is apparently rather susceptible. It was noticeable that several individual plants of Imperial were markedly free, suggesting that resistant stocks might be built up by selection.

Seed Transmission Experiments. Lettuce seeds, collected from plants severely infected with *Marssonina*, were grown in boxes in the greenhouse. Of 140 plants examined none were found to bear typical Marssonina lesions. Another lot of seed from infected plants was sown in a similar manner, and of 206 plants produced none were found to be infected. 137 of these plants were planted out in the open but no *Marssonina* developed on them. There is thus no evidence as yet that the disease is commonly transmitted on the seed.

Mosaic Disease. (Plate II, Figs I and II.)

The importance of mosaic disease of lettuces has been pointed in the 1933 report. In 1934 this disease appeared to an alarming extent.

Field Observations. Table IV gives the percentage infections of various varieties as observed in the field. It will be seen that in the case of several varieties the percentage of infection of plants grown from similar seed was practically the same although the localities of the plantings were widely apart. When it is realised that the majority of affected plants are useless for market purposes it will be appreciated that the loss from mosaic is considerable.

TABLE III.

WINTER LETTUCE TRIALS, FRENCHAY, 1933—1934.

Per cent. alive, April 12th, 1934.

Plot No.	*Sutton's Spring Beauty.*	*Sutton's Imperial*	*Parson's Lee's Immense*	*Blatchford's Arctic King.*	*Finney's Lee's Immense*	*Parson's Arctic King.*	*Thoday's Cambs. No. 1.*	*Parson's New Hercules*	*Yate's Winter White.*	*Thoday's Lee's Immense*	*Harrison's Stanstead Park.*	*Blatchford's Goliath.*	*Harrison's Schofield Hardy.*	*Wheeler's 130*	*Date Planted.*
1	30	73	74	77	65	68	52	48	82	75	79	75	56	62	Nov. 7–9
2	51	76	—	—	—	—	—	—	—	—	62	58	—	—	Nov. 9–16
3	—	—	87	—	85	—	—	—	—	—	—	—	—	—	Nov. 10–14
4	—	—	—	—	—	—	—	—	86	—	—	—	—	—	Nov. 15–18
5	59	73	—	73	—	—	47	46	75	—	—	—	—	—	About Nov. 20
6	47	72	—	—	—	—	—	—	79	—	60	51	—	—	—
Av. per cent. alive	46¾	73	80½	75	75	68	49½	47	80½	75	67	61	56	62	
Av. diameter of plants in inches	2	4½	3½	2	4	3¼	4¾	3½	3½	3½	4	4½	3	3½	

TABLE IV.

Mosaic Infection of Commercial Plantings of Winter Lettuces, 1934.

Variety.	*Source of Seed.*	*Locality.*	*Date examined.*	*Per cent. infection.*	*No. of plants counted.*
Arctic	S	Cheltenham	May 7	95	100
do.	S	Offenham	do.	98	100
do.	S	Pershore	do.	98	100
do.	S	Offenham(2)	June 6	Very severe	
do.	B	Bristol	May 10	30	100
do.	B	Cheltenham	May 7	76	300
Arctic King	C	Bristol	May 10	98	100
Goliath	B	Bristol	do.	30	100
Imperial	S	Cheltenham	May 7	17	300
do.	S	Pershore	do.	16	300
do.	S	Bristol	May 10	21	100
MacHattie's Giant ..	B	Cheltenham	May 7	25	200
Spring Beauty ..	S	Pershore	May 7	22	300
do.	S	Offenham	June 6	10	100
Stanstead Park ..	L	Cheltenham	May 7	0	100
do.	L	Cheltenham	do.	0	18
do.	H	Bristol	May 10	41	100
Unrivalled	X	Mickleton	May 14	8	300
do.	X	Offenham	June 6	6	300
Winter Wonder ..	P	Bristol	May 10	38	300
do.	P	Bristol	May 14	8	300
Yate's Winter White	X	Offenham	May 7	25	100
do.	X	Bristol	May 10	9	100
Cos var. (?)		Cheltenham	May 7	18	300

Seed Transmission. A large number of sowings were made at the Research Station of seed saved from mosaic plants of Yate's Winter White Cos and of commercial seed. It was found that of 700 plants from mosaic seed 37% were infected on June 9th, while of the similar commercial seed 11% were infected. Of the mosaic plants 73% showed a severe marginal scorch by this date.

Subsequent Spread. In one isolated planting of Spring Beauty the plants appeared perfectly normal at hearting time, except for three with mosaic symptoms removed about that time. By July 12th, 45 out of 54 plants had mosaic symptoms on the leaves of the flower stems. This observation, together with experience of commercial plantings, suggests that the disease is transmitted from plant to plant during the season.

Insect Transmission. At Long Ashton the aphis *Macrosiphum Sonchi* has been found on lettuce plants late in the autumn and in early spring, and preliminary experiments suggest that this aphis may be associated with the transmission of the disease.

Lettuce "Drop."

"Drop," caused by *Sclerotinia Sclerotiorum*, was occasionally met with during the warm summer months, but never occurred to an epidemic degree. The disease is common in semi-tropical countries, and the senior writer found that it could be controlled in Bermuda by removing the affected plants along with a little of the surrounding soil and watering the gaps with a copper sulphate solution.

DISEASES OF MINT.

Rust *(Puccinia Menthæ).*

Tar Oil Emulsion Treatments. Plants of the ordinary forcing mint (*Mentha villoso-nervata*, dark form) were watered with a 7½% Tar Oil Emulsion on November 21st, prior to lifting for forcing. The number of rusted shoots in the forced mint was 2, compared with 44 rusted shoots on a control bed of equal area. There was, however, a reduction in the number of bunches picked, from 239 in the control bed to 151 in the treated bed. This was probably due to slight injury to the rhizomes and buds.

Two other lots of *M. villoso-nervata*, dark and pale forms, were watered with a 7½% Tar Oil Emulsion containing 1% copper sulphate on January 5th. In the case of the dark form 4 rusted shoots were produced by the treated plot and 78 by an untreated plot of the same size, the numbers of bunches picked being 141 and 130 respectively. In the case of the pale form, similarly treated, the numbers of rusted shoots were 4 and 101 and the number of bunches picked 131 and 134 respectively. It should be noted that the areas of the beds were the same in every case.

From reference to previous trials of watering with tar oil emulsions, it will be seen that the reduction of the number of rusted shoots is usually considerable, but that occasionally there is a substantial reduction in the number of marketable shoots, as noted above. Hence this method does not seem to afford a very satisfactory commercial means of control.

Hot water treatments were experimented with in 1934-35, but the results of these are not yet available.

Susceptibility of Species of Mentha. Observations were made on the incidence of the uredospore stage on 47 species and varieties of Mentha at the Research Station on September 4th. Although neighbouring rows were heavily infected the following were relatively free: *Mentha niliaca nemorosa* (individual plants), *citrata, piperita sexonis, crispa* vars., *cordifolia, rubra* vars., *gentilis* and *rotundifolia.*

Seedlings of *M. villoso-nervata* were also raised, and a marked difference in susceptibility was observed.

ONION DISEASES.

White Rot *(Sclerotium cepivorum).*

An attempt was made to control this disease by the application of formalin (1 pint to 16 gallons) by means of a small tank fastened to the seed drill, as has been used successfully in dealing with onion smut. No appreciable control was obtained from this treatment.

DISEASES OF PEAS.

Fusarium Foot Rot.

The prevalence and importance of foot rots of peas in Worcestershire and other parts of the Bristol Province have already been pointed out in previous reports of this series. Premature dying off of the plants is associated sometimes with *Heterodera schachtii* plus foot rot (11), and sometimes with foot rot alone.

We have been unable up to the present to disentangle the effects of the two organisms. It is a simple matter to produce foot rots with pure cultures of the most prevalent *Fusaria*, but the characteristic dying off of the plants is absent, both in pots and in the open. Under these conditions also the foot rot symptoms do not appear till the plants are relatively mature.

In 1934, striking effects were produced by growing surface sterilised peas in large test tubes on damp sterilised soil inoculated with the *Fusaria* in question. Sterile plugs were kept in the tubes till the pea shoots reached them ; they were then removed.

Four cultures were used, all *Fusarium Solani* var. *Martii*, isolated from pea foot rots. After a month and a half all the cultures had produced severe blackening of the bases of the stems of the plants, and blackening and rotting of the main and lateral roots. There was also a marked stunting of the plants. The control plants growing in sterile soil had clean and healthy roots and vigorous top growth.

The blackening and rotting of the roots was of especial interest since this is a striking feature of the disease in the field.

More work has been done on the pathogenicity of the *Fusaria* isolated from pea foot rots and it has been shown, by means of pot and field inoculations, that all the most virulent isolations can be ascribed to *Fusarium Solani* (Mart.) var. *Martii* (App. et Wr.) Wr. forma 2 Snyder (= *F. Martii* App. et Wr. v. *Pisi* Jones) and Prof. H. W. Wollenweber has kindly confirmed this identification of cultures sent to him.

Two interesting papers dealing with *Fusarium* foot rots of peas have appeared recently. The first, " *Fusarium* Aantastingen van Erwten," by Johanna C. Went (12), is a record of work on the so-called " St. John's Disease " of peas occurring in Holland and other parts of the Continent. This disease was first investigated by Van Hall (5) in 1903, who gave it this name on account of its prevalence around the 24th of June, St. John's day.

The symptoms of this disease have now been well described by Miss Went, as follows : " In pea fields in Zeeland there appears towards the end of June or early July to a greater or less degree a series of yellow patches. These yellow plants die off before the others. The earlier this yellowing appears the more detrimental it is to the harvest. These yellow patches appear at random in the field, though at first sight it appears as if the lower lying parts of the field are being attacked. Sometimes the whole field turns yellow."

St. John's disease was formerly attributed by Van Hall to *F. vasinfectum* var. *Pisi*, but Miss Went isolated most frequently from diseased plants Fusaria belonging to the section *Martiella* and proved that the most serious symptoms of disease were induced by *F. Solani* var. *striatum* (Sherb.) Wr., *F. Solani* var. *Martii* (App. et Wr.) Wr. and *F. oxysporum* Schlecht.

As indicated above, we have found only the var. *Martii* of these varieties of *F. Solani* in the West of England and experiments to date have shown that only this fungus, of all those isolated, is in any way pathogenic. The identity of the fungus in Holland and England and of the symptoms of the disease lead us to believe that " foot rot " as known in England is identical with " St. John's Disease."

Miss Went found, as we did, that the disease appears in high and low lying spots indiscriminately. She found it mainly in clay soils and in fact could produce inoculations only in clay soil. We on the other hand have found severe foot rot on many types of soil, including light and heavy sands.

Another recent paper, by Wm. C. Snyder (10), entitled " Notes on *Fusaria* of the genus *Martiella*," deals with a taxonomic study of those members of this group of *Fusaria* which are pathogenic to peas and beans. Snyder has found that the fungi previously designated as *F. Martii*, and *F. Martii* vars. *minus*, *viride*, *Pisi* and *Phaseoli* belong to "the same morphologic type, designated by the trinomial *F. Solani* var. *Martii*, possessing some differences in spore size but differences which have not proved to be practical from the taxonomic standpoint, owing to an overlapping in this character. The final distinction between these fungi lies with their physiologic behaviour in respect to certain species of growing plants." *F. Martii* and *F. Martii* var. *minus* (= var. *viride*) have already been designated by Wollenweber as *F. Solani* var. *Martii* and *F. Solani* v. *Martii* f.1 respectively, and Synder now proposes that the pea form, sometimes known as *F. Martii* var. *Pisi* (see our previous papers), be known as *F. Solani* var. *Martii* f.2, and that the bean root rot fungus, sometimes known as *F. Martii* var. *Phaseoli*, be known as *F. Solani* var. *Martii* f.3.

Snyder concludes that "a summary of the pathology of the *Fusarium* stem and root rots emphasises the similarity in the nature of the diseases caused by the closely similar pathogens *F. Solani* v. *Martii* f.2, *F. Solani* v. *Martii* f.3, and *F. Solani* v. *eumartii* (pathogenic to potato), respectively. The diseases in each case are characterised primarily by an invasion and reddish brown to dark brown or almost black rot of the cortex of the below-ground stem and root, and are frequently followed by secondary, wilt-like symptoms."

VEGETABLE MARROW DISEASES.

Mosaic.

Removal of plants of *Bryonia dioica* from surrounding hedges was associated with the complete disappearance of the disease from two fields in which it had been very prevalent in previous years.

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PLATE I.

Heart Rot of Celery, caused by *Bacillus carotovorus.* L. R. Jones.

Fig. 1. Rotting associated with injury by larvae of the Drosophilid fly, *Scaptomyza graminum* Fall.

Fig. 2. Rotting associated with late carrot fly attack on earthed up plants.

PLATE II.

Mosaic Disease of Lettuces.

Fig. 1. Leaves of affected Cos Lettuce.

Fig. 2. Affected plants in field. Note dwarfing.

CIDER MAKING TRIALS FOR THE SEASON 1933-34.

By P. T. H. PICKFORD.

The 1933 cider apple crop showed a great improvement on that of the previous year, and in many districts was the heaviest recorded for a number of years.

The average specific gravity of all the juices examined at Long Ashton was 1.0599. This was the highest average since 1921, and was, indeed, almost as high as that year's average.

The general quality of the ciders on the whole was definitely high, as a result of the exceptional climatic conditions throughout the summer and autumn of 1933.

Following the hot dry summer and the exceptionally dry autumn a " vintage " year was naturally expected, but although the ciders generally were rich and full in flavour, there were no ciders of pre-eminent quality. Their character was in fact somewhat disappointing in view of the promising season and there was a marked absence of aroma in the majority of the samples.

The Cider Competitions.

For the ninth year in succession, competitions were arranged on similar lines to those described in previous reports, except for minor modifications. There was no competitive class for Blends and there was no class for pears. The class for blends had undoubtedly reached the limit of its usefulness, and it was decided to modify the class this year. Each single variety of fruit submitted for competition in Classes II, III and IV was, however, blended by the Institute with a suitable proportion of sharp, sweet or bittersweet type or cider required to produce a balanced marketable cider.

84 entries of fruit were received. The consignments were stored until fit for milling, and the subsequent treatment given to each cider was the same, except for the following differences as to the filtration period. In Classes I and II the ciders were filtered when the specific gravity of the juices was 1.030 ; in Classes III and IV the filtration gravity was 1.025.

The Competitions were open to growers residing in the counties of Devon, Dorset, Gloucestershire, Herefordshire, Monmouthshire, Somersetshire, Wiltshire and Worcestershire. The entries from the different counties were distributed as follows :—Devon, 19 ; Dorset, 4 ; Gloucestershire, 11 ; Herefordshire, 18 ; Monmouthshire, 1 ; Somersetshire, 26 ; Wiltshire, 0 ; Worcestershire, 5.

The Ciders were judged on April 18th, 1934, by Major E. W. Farwell, Kilmersdon, Bath, and Messrs. L. V. Bickford (Messrs. John Symons & Co., Ltd.), Totnes, Devon, and D. Phillips Morgan (Severn Vale Cider Co., Ltd.), Bushley, Worcs.

Class I (Kingston Black) had 15 entries, all of which were very good ciders, rich and pleasant in flavour with considerably more character than in the previous year. Even so, none quite reached the high standard anticipated. The tannin flavour was rather too prominent in several of the samples, and few had pronounced bouquet. No. 2, which was awarded the 1st prize, was an outstanding, full flavoured cider with a pleasing smoothness on the palate. No. 14, the 2nd award, was certainly one of the best. It had a very soft, pleasant flavour which left a very agreeable after-taste. No. 15 differed from the first two awards in that, although it had a pleasing delicate flavour, the tannin character was a little too pronounced. No. 9 was a pleasant, clean cider, but was too high in acidity. No. 3 was the most interesting sample from the point of view of aroma. No. 1, the Kingston Black from the trial orchard at Burghill, Hereford, was pleasant but thinner in flavour than any of the rest. The fruit was from comparatively young trees, and the rate of fermentation of the juice was relatively rapid.

Class II (Sharp Varieties) was divided, as in the previous years, into two groups :—A, with an acidity of 0.80% or above ; B, with an acidity below 0.80%. The ciders in Group A are only suitable for blending with ciders of low acidity, whereas those in Group B can be used unblended.

Group A, comprising 8 entries, was a very even class of ciders. They were all good for blending purposes with clean, fresh acid character. No. 19, Fair Maid of Devon, received the first award. This was a very good, clean, sharp cider and, although somewhat thin in flavour, made a very useful blender. No. 18, White Thorn Pippin, which was placed second in this class, was a fruity cider, but with a slight coarseness on the palate. The Reserve prize cider, No. 20, Broadtails, was a very pleasant acid cider but of rather weaker character than the first two awards. No. 17, the single entry of Frederick, had an extremely penetrating acid flavour, but was not unpleasant. It was an excellent blender and well deserved mention in the awards. No. 16, Kittisford Sour, a newcomer in the competitions, was Highly Commended. It was an interesting cider : although very clean in flavour, its acid character was too raw. Of the remainder in this class, No. 23, Barndoor Pippin, was a fine, sharp cider ; No. 21, Somerset Crab, was rather poorer in quality and somewhat hard in flavour ; No. 22, Cap of Liberty, was an excellent cider, but had a slight acetic flavour owing to its exceptionally slow rate of fermentation.

Group B (18 entries) was a particularly strong class of ciders, many of which were sufficiently balanced in flavour to produce beverages suitable as drinks without blending. The very even quality of several of the samples made the judging no easy task. No. 29, Langworthy, which was placed the first in the class, was almost a " vintage " medium sharp. It was a cider of fine quality, with well balanced characters. The acidity was rather low for this class, but it made an extremely pleasant drink alone. No. 36, also a Langworthy, was again a good drink unblended : although not quite up to the standard of No. 29, it was a very good, soft, medium acid drink. The 3rd award was given to No. 25, Ludlow's Sharp. This was a fairly good quality cider with a pleasant, fruity flavour and was one of the few samples with an aroma. No. 41, Lambrook Pippin (4th prize) was far too bitter as a drink alone, but otherwise was of outstanding high quality. The Reserve award was given to No. 40, Normington. This was a mild bittersharp, which might not have been out of place in the bittersweet class. It was certainly far too high in tannin for this class. No. 37, Woolston Spice, was not so full in flavour, but it was fruity and had a pleasant apple aroma. No. 28, Colman's Prolific, had a pleasant, well balanced flavour : it was, however, rather thin and sugary. No. 35, Neverblight, was a good, clean cider with a pleasant briskness, but needed to be blended to produce a balanced beverage. No. 27, Teign Harvey, was one of the best in the class. It was a very good quality cider, pleasant and full in flavour and made a most suitable drink alone. The most outstanding cider in the class from the point of view of aroma was No. 32, Langworthy ; yet the flavour of this cider was below the standard of the other Langworthys. Of the remainder in the class No. 26, Gloucester Neverblight, No. 30, Fair Maid of Devon, No. 31 (No. "18") and No. 33, Sweet Bay, were pleasant ciders, but thin in quality with no outstanding characters ; No. 24, Gloucester Pippin, No. 34, Green Sharp, No. 38, Layne's Colonel and No. 39, Dymock White Bache, were all rather coarse ciders of a poorer nature.

Class III (Sweet Varieties) was a very strong class of 25 entries, and was again a difficult class to judge owing to the evenness of the ciders. They were outstandingly interesting for "sweet" ciders, possessing characters seldom found in this type which overruled the sickly flavour so frequent in "sweet" ciders. Both the first and second awards were gained by the variety Sweet Alford. No. 48 (1st prize) was an excellent cider with a fine, fruity flavour, and well deserved the award it received. The 2nd prize exhibit, No. 54, from the Burghill Trial Orchard, Hereford, was a good sweet cider, though not so delicate in flavour as No. 48. No. 66, Slack-ma-Girdle, was certainly one of the best in this class, and was awarded 3rd prize. It had a fine "sweet" character, and a remarkably rich flavour. No. 43, Improved Kingston Black, (4th prize), was rather out of place in the Sweet class. Although it had little character, it was a pleasant cider, but too acid for this class. The variety from Dorset, No. 60, Best Bearer, was quite typical of its type from this county. It was a good flavoured cider with a fair amount of aroma, and attained the Reserve award. No. 67, Bryant's Sweet, which was very highly commended, was a pleasant cider but not quite so clean on the palate as some and it gave no aroma. No. 44, Pound Apple, produced a cider which was much more interesting than usual from this variety, but not outstanding in any way. No. 63, Smith's Sweet, another Dorset variety, was a particularly strong cider, with a rich, clean flavour. No. 64, Sweet Clusters, was a fine, clean "sweet," while No. 65, Sweet Coppin, was a very soft cider which, although lacking in character, was quite fair for blending. Although No. 58, Northwood, was not included in the list of awards it was among the best, being a fine neutral flavoured cider, pleasant and very soft. No. 52, Killerton Sweet, was also a soft and pleasant "sweet." No.42, Mounts Seedling, proved to be of fair quality, its rather high acidity giving it more character than usual with "sweet" varieties. No. 45, was a good cider and fairly typical of Sweet Alford. No. 46, Sugar Loaf, was rather too bitter, while No. 49, Blumen, lacked character. No. 56, Sweet Coppin, was quite a pleasant cider with a fruity flavour and aroma. Of the remainder in this class, No. 47, Green Sweet, No. 50, Hangdown, No. 57, Sweet Alford, and No. 62, Woodbine, were only fair in quality and lacked character. Nos. 51 and 53, the two entries of Improved Pound, No. 55, Court Royal, and No. 59, Pound Apple, were comparatively poor in quality.

Class IV (Bittersweet Varieties) was the most variable class. There were 18 entries, which produced ciders ranging from mild to very heavy bittersweets. The most interesting feature of this class was the manner in which the high alcoholic content in many cases softened the high tannin flavours. The premier award was given to No. 79, Loyal Drain. This award was probably more outstanding than the first award in any other class. The cider was an exceptionally rich bittersweet of fine character, full flavour and perfect colour. No. 82, Jenning's Bitter, the 2nd prize cider, had a pleasing, fruity flavour and was one of the few with a marked aroma. No. 81, Shapwick Bitter, had a good, clean, bitter flavour and also some aroma. No. 83, Yarlington Mill Jersey, was a fair cider, but might have been cleaner: the exceptionally slow rate of fermentation of the juice was probably responsible for a slight taint. The Reserve prize was awarded to No. 80, Chisel Jersey, which was a very full flavoured cider, particularly rich on the palate with a soft tannin character. No.72, Shapwick Apple, very highly commended, was fair in flavour, but the after-taste was not pleasing. No. 76, Cummy Norman, although a full, rich cider, had a rather coarse tannin. No. 73, Harry Master's Jersey, which was commended, was a very good cider with an outstanding fresh aroma. No. 70, the Cherry Norman, though not amongst the list of awards, was, however, an excellent bittersweet with a clean, fresh flavour and aroma. No. 68, Clusters, and No. 69, No. "9," were good ciders but were rather mild for this class and would probably have received more attention in the "sweet" class. Three of the varieties sent from the Trial Orchard at Burghill, Hereford, namely No. 71, Dabinett, No. 77, Yarlington Mill Jersey, and No. 78, Ashton No. 32, were rather thin in character though not unpleasant in flavour. It must be remembered that the fruit in each case was from comparatively young trees. No. 67, Large Hangdown, and No. 74, Green Bittersweet, were only fair in quality. No. 75, Maynards Bitter, was not a pleasant cider and No. 84, Shrawley Bittersweet, had a very harsh, penetrating tannin character which required a great deal of toning down.

Non-Competitive Ciders and Perries.

Blends made from the Competition Ciders.

A blend was made from each individual competition entry in Classes II, III and IV, by the addition of a suitable proportion of a standard sharp, sweet or bittersweet cider. The proportions used in each case are given in Table I.

The blends were remarkably even in their character, and were considered on the whole representative of well balanced marketable ciders.

They proved very useful in the judging of all the classes, but were especially helpful in the case of the sharp classes.

Ciders made from Single Varieties sent for Trial.

The varieties, Bulmer's Norman and Michelin, were sent by Messrs. H. P. Bulmer & Co., Hereford.

No. 154, Bulmer's Norman, was particularly interesting in view of the merits of this variety as an orchard tree. The cider was of the mild bittersweet type. Although not outstanding in character, it produced a pleasant cider with a distinct apple flavour and aroma of its own. A second sample of the cider was taken at a gravity of 1.015, and this resulted in a cider of rather more character which was quite wine-like in flavour.

No. 155, Michelin, was pleasant but had less character then Bulmer's Norman and was rather thin and watery. No. 156, Royal George, which has continually gained awards in the competitions in previous years, was up to its usual standard. It is a fine bittersweet, full in flavour, with a very refined tannin. No. 157, White Sharp, made a well balanced cider with a pleasant sub-acid clean flavour, but was a little too thin alone.

The Jersey variety, No. 158, Bretagne, made a good "sweet" cider, but was rather too sickly and lacked character. Blended with a sharp variety, however, it made a pleasing light cider.

No. 159, was a good quality bittersweet having a clean, fresh flavour and a well covered tannin character.

Ciders made from the Burghill Trial Orchard.

Four more varieties from this source were received in addition to those entered in the competitions. No. 160, Knotted Kernel, was an excellent bittersweet, well up to standard, and typical of this variety. No. 161, Cap of Liberty, was a good cider of its type. It had a very keen, acid flavour but was a good blender. No. 162 (No. "8") was not pleasant, having a very coarse tannin flavour. No. 163, Cowarne Red, was disappointing. It was very thin in flavour and far from being up to standard for this variety.

Ciders made from the Long Ashton Trial Orchard.

No. 164, Sweet Alford, was a very soft cider, with a pleasant neutral flavour, fruity and aromatic. No. 165, Knotted Kernel, was disappointing. It was a rich cider but was spoilt by a very hard tannin flavour. No. 166, Chisel Jersey, was also spoilt by an unrefined tannin character, but it proved useful when judiciously blended. No. 167, Neverblight, had a pleasant apple flavour and aroma and was a pleasing drink, though of very light character.

No. 168, Reinette Obry, also lacked body, and was rather thin in flavour for the season. Unblended, however, it made a pleasant, light cider. No. 169, Frequin Audievre, was more outstanding in appearance than in any other way. It was an exceptionally deep coloured bittersweet cider, with a well covered tannin, but the flavour lacked character. No. 170, Harry Master's Jersey, made a very fine, rich bittersweet beverage, although it had a slight suspicion of acetification due to the exceptionally slow rate of fermentation.

Perries.

The perries were disappointing. No. 171, an exceptionally heavy cropping variety, was sent for trial primarily for that reason. The perry, however, was rather poor and had little character. No. 172, Butt, was thin and watery, yet it possessed far too much astringency. No. 173, the perry from mixed pears from Long Ashton, was the best of all, although the quality of this was only fair.

Report of the Judges of the Long Ashton Cider Competitions 1933-1934.

The judging of the ciders in these competitions took place on April 18th, 1934.

The ciders were on the whole exceptionally high in quality, and all the classes were very strong. The average specific gravity of the freshly expressed juices was the highest since 1921, and in consequence a high alcoholic content was found throughout. The flavours in general were pleasant, although there were few highly developed aromas.

Class 1, for Kingston Black ciders, comprised 15 entries. These were all rich and full flavoured, with a good deal more character than the previous year's samples, but they had no pronounced bouquets. The first three were particularly good ciders, but the tannin character was rather too conspicuous in many of the remaining samples.

Class 2A, for ciders of high acidity, consisted of 8 entries, each useful for blending. They were good without much marked individual difference. The acid character was particularly clean and fresh, and they were all in fine condition.

Class 2B, for varieties of medium acidity, with 18 entries, was a very strong class. All were very even and proved very difficult to judge. Many of these ciders were so well balanced in their qualities as to make good drinks unblended.

Class 3, with 25 entries of sweet varieties, was again difficult to judge because of the evenness of the ciders. They had character beyond expectation for this type of fruit. The flavours were particularly pleasant without being "sickly."

Class 4, for bittersweets was the most variable class, with its 18 entries, showing a range extending from mild to very heavy bittersweets. In this class the higher tannin percentages of many varieties appeared to be softened by their alcoholic content. The first prize in this class was a very good bittersweet.

In conclusion special mention should be made of the assistance afforded by the specimen blends made at the Institute for each entry. They were especially helpful in the judging of the sharp classes. We also express our appreciation of the impartial effort made in the preparation and display of the samples. The obvious care with which the whole of the work was conducted reflects great credit on those responsible for the work.

(Signed) D. PHILLIPS MORGAN.
E. W. FARWELL.
L. V. BICKFORD.
Judges.

TABLE I.

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1934.	Name and Address of Grower.
	CLASS 1.—KINGSTON BLACKS—									
1	Kingston Black ..	6/11/33	1.062	0.45	0.14	9.7	24/11/33	1.030	1.028	Burghill Trial Orchard, Hereford.
2	,, ,, ..	7/11/33	1.071	0.66	0.23	5.2	19/1/34	1.030	1.028	W. Hill, Kittisford, Som.
3	,, ,, ..	7/11/33	1.079	0.78	0.24	5.7	24/2/34	1.030	1.030	J. G. Protheroe, Ross, Hereford.
4	,, ,, ..	7/11/33	1.069	0.61	0.22	4.2	3/2/34	1.030	1.029	J. E. Edwards, Norton Cannon, Hereford.
5	,, ,, ..	7/11/33	1.070	0.74	0.26	3.2	7/3/34	1.030	1.030	H. E. Dabinett, Somerton, Som.
6	,, ,, ..	7/11/33	1.072	0.77	0.22	5.0	23/3/34	1.030	1.030	J. Maunder, Kingsweston, Som.
7	,, ,, ..	7/11/33	1.075	0.78	0.22	5.2	10/2/34	1.030	1.029	G. P. Hallett, Charlton Adam, Som.
8	,, ,, ..	7/11/33	1.076	0.83	0.24	5.8	27/2/34	1.030	1.030	W. Ludlow, Westbury-on-Trym, Glos.
9	,, ,, ..	7/11/33	1.076	0.89	0.22	6.6	12/2/34	1.030	1.030	F. W. Mills, Stourport, Worcs.
10	,, ,, ..	8/11/33	1.080	0.80	0.26	6.8	13/3/34	1.030	1.030	P.E. Bomford, Upton Snodsbury, Worcs.
11	,, ,, ..	8/11/33	1.067	0.59	0.22	4.0	5/3/34	1.030	1.030	E. T. Bryant, Taunton, Som.
12	,, ,, ..	8/11/33	1.077	0.86	0.22	6.4	5/3/34	1.030	1.030	A. Phelps, Minsterworth, Glos.
13	,, ,, ..	8/11/33	1.077	0.71	0.26	5.9	22/2/34	1.030	1.030	J. Dennis & Sons, Churcham, Glos.
14	,, ,, ..	8/11/33	1.072	0.71	0.23	4.8	24/2/34	1.030	1.030	H. Knight, Huntley, Glos.
15	,, ,, ..	14/11/33	1.077	0.71	0.27	2.9	23/3/34	1.030	1.030	W. R. Thomas, Nunnington, Hereford.
	CLASS 2A.—SHARP VARIETIES. Acidity of 0.8 per cent. or above.									
16	Kittisford Sour ..	17/10/33	1.061	0.96	0.20	7.7	15/11/33	1.030	1.028	W. Hill, Kittisford, Som.
17	Frederick	17/10/33	1.060	1.25	0.08	6.7	11/11/33	1.030	1.030	A. L. Thomas, Monmouth, Mon.
18	White Thorn Pippin	17/10/33	1.056	0.96	0.16	14.0	27/10/33	1.030	1.025	T. Fawkes, Stonehouse, Glos.
19	Fair Maid of Devon	23/10/33	1.045	0.90	0.11	8.3	1/11/33	1.030	1.029	A. H. Waters, Newton St. Cyres, Devon.
20	Broadtails.. ..	24/10/33	1.066	0.93	0.16	10.0	18/11/33	1.030	1.029	E. R. Edmonds, Shrawley, Worcs.
21	Somerset Crab ..	17/11/33	1.053	1.23	0.26	5.4	4/12/33	1.030	1.028	E. C. Smith, Stoke Abbott, Dorset.
22	Cap of Liberty ..	17/11/33	1.066	1.08	0.29	2.2	7/3/34	1.030	1.029	W. Maynard, Martock, Som.
23	Barndoor Pippin	27/11/33	1.062	0.83	0.28	8.8	1/1/34	1.030	1.027	J. Maunder, Kingsweston, Som.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1934.	Name and Address of Grower.
	CLASS 2B.—MEDIUM SHARP VARIETIES. Acidity below 0.8 per cent.									
24	Gloucester Pippin	17/10/33	1.057	0.57	0.19	12.5	30/10/33	1.030	1.020	T. Fawkes, Stonehouse, Glos.
25	Ludlow's Sharp ..	23/10/33	1.057	0.57	0.22	9.2	7/11/33	1.030	1.020	W. Ludlow, Westbury-on-Trym, Glos.
26	Gloucester Neverblight	24/10/33	1.059	0.69	0.13	9.7	8/11/33	1.030	1.024	,, ,, ,,
27	Teign Harvey ..	24/10/33	1.054	0.62	0.23	3.4	27/11/33	1.030	1.030	F. Vincent, Pinhoe, Devon.
28	Colman's Prolific ..	30/10/33	1.049	0.47	0.14	6.0	11/11/33	1.030	1.028	R. C. Brook, Newton St. Cyres, Devon.
29	Langworthy (Sour Natural) ..	31/10/33	1.056	0.45	0.16	4.7	1/12/33	1.030	1.030	,, ,, ,, ,,
30	Fair Maid of Devon	1/11/33	1.053	0.73	0.10	11.0	9/11/33	1.030	1.022	Burghill Trial Orchard, Hereford.
31	No. 18	3/11/33	1.061	0.46	0.12	7.7	18/11/33	1.030	1.028	,, ,, ,, ,,
32	Langworthy ..	17/11/33	1.044	0.46	0.13	6.0	30/11/33	1.030	1.029	A Pope, Crediton, Devon.
33	Sweet Bay ..	17/11/33	1.059	0.49	0.23	3.3	13/1/34	1.030	1.028	,, ,, ,,
34	Green Sharp ..	17/11/33	1.060	0.46	0.24	11.0	4/12/33	1.030	1.027	Mrs. J. Clark, Honiton, Devon.
35	Neverblight ..	17/11/33	1.055	0.54	0.21	5.2	12/12/33	1.030	1.029	S. H. Osborn, North Cadbury, Somerset.
36	Langworthy ..	20/11/33	1.048	0.46	0.11	4.1	27/1/34	1.030	1.030	E. T. Bryant, Taunton, Som.
37	Woolston Spice ..	27/11/33	1.045	0.46	0.13	5.0	14/12/33	1.030	1.028	S. H. Osborn, North Cadbury, Som.
38	Layne's Colonel ..	27/11/33	1.060	0.75	0.22	4.2	8/1/34	1.030	1.026	F. E. Fowler, Hartpury, Glos.
39	Dymock White Bache	28/11/33	1.061	0.77	0.18	11.5	12/1/34	1.030	1.023	E. T. Lewis, Dymock, Glos.
40	Normington ..	28/11/33	1.064	0.47	0.34	10.7	8/1/34	1.030	1.026	,, ,, ,,
41	Lambrook Pippin	28/11/33	1.066	0.62	0.32	5.8	18/1/34	1.030	1.028	J. Maunder, Kingsweston, Som.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

CLASS 3.—SWEET VARIETIES—

42	Mount Seedling ..	24/10/33	1.058	0.42	0.16	7.2	23/11/33	1.025	1.025	H. E. R. Warren, Netherbury, Dorset.
43	Improved Kingston Black	6/11/33	1.061	0.41	0.16	11.5	21/11/33	1.025	1.025	Burghill Trial Orchard, Hereford.
44	Pound Apple ..	17/10/33	1.057	0.36	0.15	9.5	4/11/33	1.025	1.025	W. Hill, Kittisford, Som.
45	Sweet Alford ..	23/10/33	1.052	0.37	0.15	6.0	20/11/33	1.025	1.025	A. H. Walters, Newton St. Cyres, Devon
46	Sugar Loaf ..	24/10/33	1.057	0.19	0.20	7.5	24/11/33	1.025	1.025	F. Vincent, Pinhoe, Devon.
47	Green Sweet ..	30/10/33	1.051	0.25	0.17	7.5	13/11/33	1.025	1.019	J. Maynard, Martock, Som.
48	Sweet Alford ..	30/10/33	1.054	0.14	0.15	6.7	23/12/33	1.025	1.025	R. C. Brook, Newton St. Cyres, Devon.
49	Blumen	31/10/33	1.054	0.26	0.19	5.2	27/11/33	1.025	1.024	A. Pope, Crediton, Devon.
50	Hangdown ..	31/10/33	1.061	0.16	0.19	7.3	20/1/34	1.025	1.024	H. C. Jennings, Shapwick, Som.
51	Improved Pound ..	31/10/33	1.061	0.23	0.15	13.0	13/11/33	1.025	1.019	Mrs. J. Clarke, Honiton, Devon.
52	Killerton Sweet ..	1/11/33	1.052	0.28	0.18	7.7	22/11/33	1.025	1.024	Burghill Trial Orchard, Hereford.
53	Improved Pound ..	3/11/33	1.057	0.25	0.14	8.2	14/11/33	1.025	1.016	,, ,, ,, ,,
54	Sweet Alford ..	3/11/33	1.060	0.20	0.16	7.2	2/12/33	1.025	1,025	,, ,, ,, ,,
55	Court Royal ..	3/11/33	1.058	0.33	0.12	10.0	15/11/33	1.025	1.016	,, ,, ,, ,,
56	Sweet Coppin ..	6/11/33	1.058	0.23	0.17	8.0	24/11/33	1.025	1.025	,, ,, ,, ,,
57	Sweet Alford ..	17/11/33	1.059	0.22	0.20	3.2	1/3/34	1.025	1.025	A. Pope, Crediton, Devon.
58	Northwood ..	20/11/33	1.053	0.28	0.16	7.2	6/1/34	1.025	1.024	,, ,, ,,
59	Pound Apple ..	20/11/33	1.059	0.24	0.20	7.0	20/1/34	1.025	1.025	F. Vincent, Pinhoe, Devon.
60	Best Bearer ..	20/11/33	1.057	0.23	0.15	7.5	13/1/34	1.025	1.022	J. Bowditch, Stoke Abbott, Dorset.
61	Bryant's Sweet ..	20/11/33	1.051	0.21	0.16	7.5	23/12/33	1.025	1.023	E. T. Bryant, Taunton, Somerset.
62	Woodbine ..	27/11/33	1.053	0.18	0.13	4.2	27/12/33	1.025	1.023	,, ,, ,,
63	Smith's Sweet ..	27/11/33	1.066	0.26	0.19	6.8	2/2/34	1.025	1.024	E. C. Smith, Stoke Abbott, Dorset.
64	Sweet Clusters ..	27/11/33	1.060	0.20	0.20	6.0	23/1/34	1.025	1.023	H. Daniel, Honiton, Devon.
65	Sweet Coppin ..	27/11/33	1.050	0.28	0.13	2.5	19/1/34	1.025	1.024	F. Vincent, Pinhoe, Devon.
66	Slack-ma-Girdle ..	27/11/33	1.062	0.27	0.20	4.2	16/3/34	1.025	1.024	A. Pope, Crediton, Devon.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1934.	Name and Address of Grower.
	CLASS 4.—BITTERSWEET VARIETIES—									
67	Large Hangdown . .	17/10/33	1.053	0.20	0.25	5.5	20/11/33	1.025	1.024	R. Collins, Chagford, Devon.
68	Clusters	24/10/33	1.061	0.30	0.22	8.2	17/11/33	1.025	1.023	W. Hill, Kittisford, Som.
69	No. 9	1/11/33	1.056	0.19	0.22	8.0	15/11/33	1.025	1.023	Burghill Trial Orchard, Hereford.
70	Cherry Norman . .	6/11/33	1.059	0.21	0.23	6.7	30/11/33	1.025	1.023	,, ,, ,, ,,
71	Dabinett	16/11/33	1.060	0.15	0.23	7.7	14/12/33	1.025	1.023	,, ,, ,, ,,
72	Shapwick Apple . .	20/11/33	1.058	0.39	0.23	4.7	26/2/34	1.025	1.023	H. C. Jennings, Shapwick, Som.
73	Harry Master's Jersey	27/11/33	1.060	0.25	0.23	5.4-	16/1/34	1.025	1.023	S. H. Osborn, North Cadbury, Som.
74	Green Bittersweet	27/11/33	1.062	0.22	0.21	7.6	13/1/34	1.025	1.022	F. W. Mills, Stourport, Worcs.
75	Maynard's Bitter . .	17/10/33	1.062	0.37	0.29	10.0	1/11/33	1.025	1.022	W. Maynard, Martock, Som.
76	Cummy Norman . .	30/10/33	1.067	0.27	0.29	8.2	14/11/33	1.025	1.023	J. E. Edwards, Norton Cannon, Hereford
77	Yarlington Mill Jersey	1/11/33	1.052	0.18	0.28	5.8	12/12/33	1.025	1.023	Burghill Trial Orchard, Hereford.
78	Ashton No. 32 . .	16/11/33	1.056	0.20	0.24	6.2	12/1/34	1.025	1.023	,, ,, ,, ,,
79	Loyal Drain . .	17/11/33	1.065	0.25	0.50	2.1	24/3/34	1.025	1.023	H. C. Jennings, Shapwick, Som.
80	Chisel Jersey . .	20/11/33	1.062	0.22	0.39	5.6	13/3/34	1.025	1.024	S. H. Osborn, North Cadbury, Som.
81	Shapwick Bitter . .	20/11/33	1.056	0.16	0.26	5.1	3/3/34	1.025	1.023	H. C. Jennings, Shapwick, Som..
82	Jenning's Bitter . .	20/11/33	1.055	0.19	0.29	4.5	1/2/34	1.025	1.024	,, ,, ,,
83	Yarlington Mill Jersey	20/11/33	1.057	0.21	0.35	3.3	26/2/34	1.025	1.024	S. H. Osborn, North Cadbury, Som.
84	Shrawley Bittersweet	27/11/33	1.067	0.32	0.48	5.7	26/2/34	1.025	1.024	E. R. Edmonds, Shrawley, Worcs.

TABLE I.—*continued.*

CIDERS. NON-COMPETITIVE CIDERS AND PERRIES.

No.	Competition Variety.	Proportions— Com-petition Variety.	Sharp Variety.	Sweet Variety.	Bitter-sweet Variety.	Composition of Blends— Malic Acid per cent.	Tannin per cent.	Specific Gravity.
	BLENDS MADE AT THE INSTITUTE FROM INDIVIDUAL ENTRIES IN CLASSES 2, 3 AND 4.							
85	Kittisford Sour (16)	1	–	1	–	0.63	0.23	1.024
86	Frederick (17)	1	–	1	1	0.61	0.26	1.024
87	White Thorn Pippin (18)	2	–	1	1	0.64	0.23	1.023
88	Fair Maid of Devon (19)	1	–	–	1	0.56	0.23	1.026
89	Broadtails (20)	1	–	1	1	0.56	0.24	1.025
90	Somerset Crab (21)	1	–	2	–	0.62	0.25	1.025
91	Cap of Liberty (22)	2	–	3	–	0.59	0.26	1.024
92	Barndoor Pippin (23)	1	–	1	–	0.58	0.27	1.025
93	Gloucester Pippin (24)	3	1	2	–	0.61	0.21	1.020
94	Ludlow's Sharp (25)	5	2	2	1	0.60	0.22	1.020
95	Gloucester Neverblight (26)	3	1	1	1	0.63	0.20	1.021
96	Teign Harvey (27)	3	1	2	–	0.54	0.23	1.024
97	Colman's Prolific (28)	5	2	2	1	0.58	0.17	1.024
98	Langworthy (Sour Natural) (29)	5	2	2	1	0.55	0.19	1.025
99	Fair Maid of Devon (30)	2	–	–	1	0.56	0.20	1.025
100	No. 18 (31)	1	1	–	1	0.58	0.19	1.022
101	Langworthy (32)	5	2	2	1	0.52	0.18	1.024
102	Sweet Bay (33)	2	1	1	–	0.56	0.19	1.023
103	Green Sharp (34)	2	1	1	–	0.57	0.23	1.022
104	Neverblight (35)	5	2	2	1	0.56	0.21	1.023
105	Langworthy (36)	2	1	–	1	0.52	0.19	1.023

TABLE I.—*continued.*

CIDERS. NON-COMPETITIVE CIDERS AND PERRIES.

No.	Competition Variety.	Proportions— Com-petition Variety.	Sharp Variety.	Sweet Variety.	Bitter-sweet Variety.	Composition of Blends— Malic Acid per cent.	Tannin per cent.	Specific Gravity.
	BLENDS MADE AT THE INSTITUTE FROM INDIVIDUAL ENTRIES IN CLASSES 2, 3 AND 4—*contd.*							
106	Woolston Spice (37)	2	1	–	1	0.60	0.18	1.023
107	Layne's Colonel (38)	1	–	1	–	0.60	0.26	1.024
108	Dymock White Bache (39)	3	–	2	1	0.61	0.25	1.023
109	Normington (40)	4	3	4	–	0.58	0.25	1.023
110	Lambrook Pippin (41)	3	2	3	–	0.61	0.25	1.023
111	Mount Seedling (42)	3	3	–	2	0.58	0.24	1.022
112	Improved Kingston Black (43)	1	1	–	3	0.56	0.20	1.023
113	Pound Apple (44)	1	1	–	1	0.55	0.22	1.022
114	Sweet Alford (45)	1	1	–	1	0.53	0.23	1.022
115	Sugar Loaf (46)	2	2	–	1	0.56	0.24	1.022
116	Green Sweet (47)	2	3	–	2	0.57	0.23	1.020
117	Sweet Alford (48)	1	2	–	1	0.60	0.20	1.022
118	Blumen (49)	2	2	–	1	0.58	0.22	1.021
119	Hangdown (50)	2	3	–	2	0.56	0.22	1.021
120	Improved Pound (51)	3	4	–	3	0.58	0.20	1.020
121	Killerton Sweet (52)	3	4	–	3	0.59	0.22	1.022
122	Improved Pound (53)	4	7	–	5	0.58	0.21	1.019
123	Sweet Alford (54)	3	4	–	3	0.54	0.20	1.022
124	Court Royal (55)	2	3	–	2	0.60	0.21	1.019
125	Sweet Coppin (56)	4	7	–	5	0.59	0.22	1.022
126	Sweet Alford (57)	4	5	–	3	0.60	0.22	1.022
127	Northwood (58)	3	5	–	4	0.60	0.23	1.021
128	Pound Apple (59)	2	2	–	1	0.58	0.21	1.022

TABLE I.—*continued.*

CIDERS. NON-COMPETITIVE CIDERS AND PERRIES.

BLENDS MADE AT THE INSTITUTE FROM INDIVIDUAL ENTRIES IN CLASSES 2, 3 AND 4—*contd.*

129	Best Bearer (60)	3	4	–	3	0.58	0.21	1.020
130	Bryant's Sweet (61)	2	4	–	3	0.60	0.22	1.020
131	Woodbine (62)	3	5	–	4	0.56	0.22	1.021
132	Smith's Sweet (63)	2	4	–	3	0.59	0.23	1.021
133	Sweet Clusters (64)	3	5	–	4	0.59	0.23	1.022
134	Sweet Coppin (65)	3	4	–	3	0.59	0.20	1.021
135	Slack-ma-Girdle (66)	3	4	–	2	0.60	0.21	1.021
136	Large Hangdown (67)	3	5	3	–	0.59	0.19	1.021
137	Clusters (68)	2	3	2	–	0.58	0.19	1.023
138	No. 9 (69)	3	5	4	–	0.60	0.18	1.021
139	Cherry Norman (70)	4	7	6	–	0.58	0.21	1.021
140	Dabinett (71)	3	4	2	–	0.61	0.20	1.022
141	Shapwick Apple (72)	1	1	1	–	0.53	0.19	1.022
142	Harry Master's Jersey (73)	2	2	1	–	0.58	0.20	1.021
143	Green Bittersweet (74)	3	5	3	–	0.58	0.17	1.021
144	Maynard's Bitter (75)	1	1	1	–	0.58	0.21	1.020
145	Cummy Norman (76)	1	1	–	–	0.57	0.20	1.021
146	Yarlington Mill Jersey (77)	1	1	–	–	0.57	0.18	1.022
147	Ashton No. 32 (78)	1	1	–	–	0.59	0.18	1.022
148	Loyal Drain (79)	1	2	2	–	0.62	0.24	1.022
149	Chisel Jersey (80)	3	4	4	–	0.60	0.24	1.022
150	Shapwick Bitter (81)	1	1	–	–	0.60	0.20	1.022
151	Jenning's Bitter (82)	2	4	3	–	0.62	0.21	1.020
152	Yarlington Mill Jersey (83)	2	3	2	–	0.60	0.21	1.021
153	Shawley Bittersweet (84)	2	3	4	–	0.62	0.23	1.021

N.B.—The standard ciders used throughout for the Blends were as follows :—

Sharp variety	Frederick and Fair Maid of Devon.
Sweet variety	Sweet Alford and Woodbine.
Bitter sweet variety	Chisel Jersey.

TABLE I.—*continued.*

CIDERS.

NON-COMPETITIVE CIDERS AND PERRIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1934.	Name and Address of Grower.
	CIDERS MADE FROM SINGLE VARIETIES SENT FOR TRIAL.									
154	Bulmer's Norman	16/10/33	1.059	0.25	0.29	9.7	28/10/33	1.025	1.024	H. P. Bulmer & Co., Hereford.
155	Michelin	29/11/33	1.047	0.22	0.24	5.7	13/1/34	1.025	1.024	,, ,, ,,
156	Royal George ..	2/10/33	1.068	0.47	0.26	9.0	21/10/33	1.025	1.024	W. Hunt, Easton-in-Gordano, Som.
157	White Sharp ..	29/11/33	1.058	0.64	0.17	6.6	13/1/34	1.030	1.026	H. E. Dabinett, Somerton, Som.
158	Bretagne	7/12/33	1.060	0.35	0.21	8.0	15/1/34	1.025	1.024	E. M. Egre, Jersey, C.I.
159	Unnamed	29/11/33	1.058	0.29	0.29	7.5	13/1/34	1.025	1.023	W. Maynard, Martock, Somerset.
	CIDERS MADE FROM THE BURGHILL TRIAL ORCHARD, HEREFORD.									
160	Knotted Kernel ..	1/11/33	1.066	0.29	0.42	7.2	8/12/33	1.025	1.023	Burghill Trial Orchard, Hereford.
161	Cap of Liberty ..	6/11/33	1.060	0.70	0.24	9.5	22/11/33	1.030	1.029	,, ,, ,, ,,
162	No. 8	6/11/33	1.067	0.18	0.37	10.0	25/11/33	1.025	1.023	,, ,, ,, ,,
163	Cowarne Red ..	6/11/33	1.059	0.50	0.24	9.0	23/11/33	1.030	1.027	,, ,, ,, ,,
	CIDERS MADE FROM THE LONG ASHTON TRIAL ORCHARD.									
164	Sweet Alford ..	17/10/33	1.062	0.25	0.16	7.8	7/11/33	1.025	1.024	Long Ashton Trial Orchard.
165	Knotted Kernel ..	31/10/33	1.074	0.24	0.33	9.0	4/12/33	1.025	1.023	,, ,, ,, ,,
166	Chisel Jersey ..	31/10/33	1.060	0.23	0.36	6.6	19/1/34	1.025	1.023	,, ,, ,, ,,
167	Neverblight ..	31/10/33	1.046	0.51	0.23	2.6	29/11/33	1.030	1.030	,, ,, ,, ,,
168	Reinette Obry ..	1/11/33	1.056	0.51	0.08	7.0	13/11/33	1.030	1.025	,, ,, ,, ,,
169	Frequin Audievre	29/11/33	1.047	0.24	0.43	5.2	27/1/34	1.025	1.023	,, ,, ,, ,,
170	Harry Master'sJersey	29/11/33	1.052	0.22	0.27	4.5	27/2/34	1.025	1.024	,, ,, ,, ,,
	PERRIES. MISCELLANEOUS VARIETIES.									
171	Unnamed	3/10/33	1.051	0.48	0.12	9.0	11/10/33	1.030	1.027	F. P. & C. P. Norbury, Malvern, Worcs.
172	Butt Pear ..	11/11/33	1.064	0.73	0.35	5.8	9/1/34	1.033	1.030	D. P. Morgan, Bushley, Worcs.
173	Mixed Pears ..	26/9/33	1.068	0.74	0.19	5.0	21/10/33	1.033	1.030	Long Ashton Trial Orchard.

TABLE II.

Competition Ciders, 1933–34.

JUDGES' AWARDS.

Class 1.	*No.*	Kingston Black (15 *Entries*). 3 *Prizes.*
First Prize ..	2	W. Hill, Kittisford, Som.
Second Prize ..	14	H. Knight, Huntley, Glos.
Third Prize ..	15	W. R. Thomas, Nunnington, Hereford.
Reserve	9	F. W. Mills, Stourport, Worcs.
Very Highly Com'ded	3	J. G. Protheroe, Ross, Hereford.
,, ,, ,,	11	E. T. Bryant, Taunton, Som.
,, ,, ,,	12	A. Phelps, Minsterworth, Glos.
Highly Commended	8	W. Ludlow, Westbury-on-Trym, Glos.

Class 2a.		Sharp Varieties. (Acidity of 0.8% or above). (8 *Entries*). 2 *Prizes.*	*Variety.*
First Prize ..	19	A. H. Walters, Newton St. Cyres, Devon	Fair Maid of Devon.
Second Prize ..	18	T. Fawkes, Stonehouse, Glos.	White Thorn Pippin.
Reserve	20	E. R. Edmonds, Shrawley, Worcs.	Broadtails.
Very Highly Com'ded	17	A. L. Thomas, Monmouth, Mon.	Frederick.
Highly Commended	16	W. Hill, Kittisford, Som. ..	Kittisford Sour.

Class 2b.		Medium Sharp Varieties. (Acidity below 0.8%). (18 *Entries*). 4 *Prizes.*	
First Prize ..	29	R. C. Brook, Newton St.Cyres, Devon	Langworthy.
Second Prize ..	36	E. G. Bryant, Taunton, Som.	Langworthy.
Third Prize ..	25	W. Ludlow, Westbury-on-Trym, Glos.	Ludlow's Sharp.
Fourth Prize ..	41	J. Maunder, Kingsweston,Som.	Lambrook Pippin.
Reserve	40	E. T. Lewis, Dymock, Glos...	Normington.
Very Highly Com'ded	37	H. S. Osborne, North Cadbury, Som.	Woolston Spice.
Highly Commended	28	R. C. Brook, Newton St.Cyres, Devon	Colman's Prolific.
,, ,,	35	S. H. Osborne, North Cadbury, Som.	Neverblight.

Class 3.		Sweet Varieties (25 *Entries*). 4 *Prizes.*	
First Prize ..	48	R. C. Brook, Newton St.Cyres, Devon	Sweet Alford.
Second Prize ..	54	Burghill Trial Orchard, Hereford	Sweet Alford.
Third Prize ..	66	A. Pope, Crediton, Devon ..	Slack-ma-Girdle.
Fourth Prize ..	43	Burghill Trial Orchard, Hereford	Improved Kingston Black.

Reserve	60	J. Bowditch, Stoke Abbott, Dorset	Best Bearer.
Very Highly Com'ded	61	E. T. Bryant, Taunton, Som.	Bryant's Sweet.
Highly Commended	44	W. Hill, Kittisford, Som.	Pound Apple.
,, ,,	63	E. C. Smith, Stoke Abbott, Dorset	Smith's Sweet.
,, ,,	64	H. Daniel, Honiton, Devon	Sweet Clusters.
,, ,,	65	F. Vincent, Pinhoe, Devon	Sweet Coppin.

Class 4. BITTERSWEET VARIETIES (18 *Entries*). 4 *Prizes*.

First Prize	79	H.C.Jennings, Shapwick, Som.	Loyal Drain.
Second Prize	82	H.C.Jennings, Shapwick, Som.	Jenning's Bitter.
Third Prize	81	H.C.Jennings, Shapwick, Som.	Shapwick Bitter.
Fourth Prize	83	S. H. Osborne, North Cadbury, Som.	Yarlington Mill Jersey.
Reserve	80	S. H. Osborne, North Cadbury, Som.	Chisel Jersey.
Very Highly Com'ded	72	H.C.Jennings, Shapwick, Som.	Shapwick Apple.
Highly Commended	76	J. E. Edwards, Norton Cannon, Hereford	Cummy Norman.
Commended	73	S. H. Osborne, North Cadbury, Som.	Harry Master's Jersey.
,,	71	Burghill Trial Orchard, Hereford	Dabinett.

EXPERIMENTS ON THE IMPROVEMENT OF THE JUICE FROM CULINARY AND DESSERT APPLES BY MACERATION WITH PRESSED BITTERSWEET POMACE.

PROGRESS REPORT II.

By P. T. H. PICKFORD.

This series of experiments, commenced in 1932 and described in the Long Ashton Report 1933, was continued in the cider-making season of 1933-34.

The problem of the utilisation of lower grade market apples for cider which instigated the experiments has already been fully described in the previous year's Report.

The first year's experiments showed that a distinct alteration in the flavour and a definite improvement of the juice from market apples were brought about by maceration with pressed bittersweet pomace. The later experiments described herein have confirmed the initial results and have shown that the maceration period may be substantially shortened.

Experimental.

In the 1932 experiments, the once-pressed pomace from bittersweet apples was re-soaked with the juice obtained from an equivalent weight of market varieties. The juice was then allowed to macerate for a period of 12 hours and in one case also for 24 hours.

In the 1933 investigations, this treatment was repeated, but in addition one batch of juice was pressed immediately with the pressed bittersweet pomace. Bramley's Seedling was taken for the market variety and Dabinett as a representative bittersweet. The detailed treatments and the analyses of the juices are shown in Table I.

TABLE I.

Variety.	*Treatment of Juice.*	*Date of Making.*	*Specific Gravity of Fresh juice.*	*Malic Acid per cent.*	*Tannin per cent.*	*Rate of fermentation.*	*Date of filtering.*	*Specific Gravity at time of filtering.*	*Specific Gravity May, 1934.*
Bramley's Seedling	Untreated	4/12/33	1.054	0.93	0.12	8.0	20/1 34	1.030	1.029
do. ..	Pressed immediately with Dabinett pomace ..	4/12/33	1.056	0.79	0.12	8.2	16/1/34	1.030	1.030
do. ..	Macerated with Dabinett pomace 14 hours ..	4/12/33	1.0555	0.74	0.10	6.5	6/1/34	1.030	1.030
do. ..	Macerated with Dabinett pomace 26 hours ..	4/12/33	1.0555	0.74	0.08	6.2	15/1/34	1.030	1.028
Dabinett ..	Untreated	4/12/33	1.061	0.28	0.25	5.6	25/2/34	1.025	1.025

Discussion of Results.

The 1933 apple crop produced many exceptionally good juices with abnormally high specific gravities. It will be seen that the gravity of the Bramley's Seedling juice was far above the average for this variety. The juice of this variety was fair in quality of flavour in spite of the acidity being very penetrating and raw. The Dabinett juice was typical—a bittersweet of fine character with a good soft tannin flavour.

In the case of Bramley's Seedling juice which was pressed immediately with the Dabinett pomace, it will be seen that the specific gravity was increased after the treatment, the acidity was appreciably lowered, but the tannin content did not appear to be affected. The rate of fermentation of the juice was practically unchanged by the treatment, but in May, 1934, the specific gravity of the bottled sample remained unchanged, whereas the sample of the untreated juice had fallen slightly.

There was little difference in the analyses in the last two treatments in which the Bramley's Seedling juice was allowed to macerate for 14 and 26 hours respectively. The specific gravity was slightly increased in each case and the acidity was considerably lowered by an equal amount by the treatments.

The tannin value was lower in each case than that of the untreated juice, the 26-hour treatment showing lower tannin than the 14-hour treatment.

Although the content of tannin, as shown by the standard permanganate-indigo carmine method of analysis, was lower in those cases of the treated juice in spite of the use of the bittersweet Dabinett pomace, it must not be assumed that the treatment had failed to achieve its purpose of increasing the " tannin " or bittersweet chracter of the original Bramley's Seedling juice. The tannin in apple pomace and in freshly expressed juice takes up oxygen rapidly from the air and in its oxidised form is not registered by the method of analysis used, although from the flavour point of view the bittersweet character remains after the oxidation. Under the conditions of the maceration treatment, the opportunity for oxidation is increased and juices from macerated pomace thus invariably show on analysis a lower figure for tannin notwithstanding that their bittersweet character of flavour is unaffected.

In these treated Bramley's Seedling juices, the bittersweet character was considerably enhanced in all cases by the contact with the Dabinett pomace. The measure of its increase is calculable approximately from a comparison of the acidity figures. For example, taking the case of the 14-hour macerated sample, the acidity was 0.74 per cent., that of the untreated Bramley or Dabinett juices 0.93 per cent., and 0.28 per cent. respectively. These figures indicate that the treated juice had become in effect a blend of the Bramley and Dabinett juices in the approximate proportions of two parts of Bramley to one part of Dabinett. On that basis of a blend the unoxidised tannin content of the treated liquor would be 0.163 per cent., a material advance on the 0.12 per cent. in the original Bramley juice which is reflected in the added bittersweet character of the flavour.

A similar type of calculation in respect of the specific gravities of the respective juices confirms the accuracy of the conclusion drawn.

The rate of fermentation in both these juices was approximately the same and was considerably slower than that of the untreated juice. However, when the bottled samples were examined in the following May, the cider which had been subjected to the 14-hour treatment remained unchanged in specific gravity, whereas the 26-hour provided a fall in specific gravity of 2 points.

As in the previous year's work, the changes effected in the acidity and bittersweet character of the Bramley juice were the outstanding features in the experiments.

When the samples were examined some months after making, results corresponding to those of the previous year were noted. A distinct alteration and a very marked improvement in the flavour and the appearance of the Bramley's Seedling cider had been brought about in each case by the treatment with the Dabinett pomace. The resulting ciders had definitely more character than the untreated sample. They were fuller in flavour, clean and palatable with a pleasant, softened acidity. There was comparatively little difference between the results from the three treatments: the effect of immediately re-pressing the bittersweet pomace with the juice from the market variety was the most striking and interesting point. Although the acidity was not lowered quite so much by this treatment yet the cider was slightly softer in flavour than that subjected to the process of maceration for some time.

That no advantage is gained by prolonging the maceration period beyond 12 to 14 hours was apparent from the previous year's results. This was confirmed in the present experiments. A new point of importance emerged from the latter in that the method of immediate re-pressing of the pomace gave approximately the same degree of improvement as prolonged maceration treatment. Moreover, immediate re-pressing was found to be a quicker and simpler method, entailing less labour in the ciderhouse.

CONTAINERS FOR APPLE JUICE AND CIDER.

I.—WOODEN VESSELS.

A.—THE SUITABILITY OF VARIOUS CONIFEROUS WOODS. 1.

By P. T. H. PICKFORD.

The provision of vats, casks and other vessels as juice and cider containers for fermentation, storage and other purposes is an expensive item in the cider-maker's budget. This point has been forced into prominence by the comparatively heavy apple crops of the last two successive seasons of 1933 and 1934, which have overtaxed the existing storage capacity of many makers and have made it necessary for them to face additional capital expenditure for extension in this direction.

While the larger factories with their greater financial resources have at present a choice between vessels constructed of reinforced concrete, enamelled or acid-resistant metals, and wood respectively, smaller concerns and farmer cider-makers are restricted to the use of wood almost exclusively on account of the heavy initial outlay involved for vessels of other materials. There is undoubtedly a wide and promising field for investigation in the direction of vessel construction and materials suitable for that purpose : but comprehensive research in that subject is too costly for this Station to undertake under existing financial conditions. To a limited extent, attention is being given to it as occasion offers and recently it has been decided to examine as closely as circumstances permit, and as a preliminary to active research over the wider field, the suitability of various kinds of woods for such purposes.

The study of woods at the outset in this connection has been decided upon primarily because of the fact that wood is almost invariably used in some form in cider making operations. A contributory factor to this decision has been the number of recent enquiries received as to the suitability of various kinds of woods—especially those of coniferous types—for the purpose.

Hitherto only two kinds of woods—oak and chestnut—have been accepted as suitable for use, with the former definitely for preference, although the more expensive. A wide range of choice, especially in relation to cost, is very desirable if such can be found. The present investigation is directed therefore to an examination of any likely types of wood in this respect.

Although there may be other kinds of wood which will not impart any undesirable taste, odour and colour to cider, yet some or all of these may not be suitable, either on account of price. or because they do not conform to the necessary standards of length, width, thickness or freedom from defect. It is proposed. consequently, to limit the examination to such woods as conform to these standards, and are available at a favourable price, tests on their effect on the flavour of cider being made at the outset. The present article deals with the first stage of this programme already carried out and is concerned with the examination of various coniferous timbers.

Experimental.

In 1934, five samples of coniferous timbers, all of which qualify from the vat-maker's point of view, were obtained by the courtesy of Messrs. Carty and Son, Ltd., London, for the purpose of making the preliminary tests.

They were as follows :—Prime Clear British Columbian Pine, Siberian Red Fir (Redwood), Archangel White Fir, New Zealand Kauri Pine, Louisiana Red Cypress.

The general method of procedure adopted in these initial tests consisted in the immersion of small blocks of the respective woods in various types of cider, their effect on the flavour of the ciders being noted after a period of time. Further examination of these woods is now in progress by re-immersing them in fresh lots of cider for another period to determine if the effect on flavour is reduced or eliminated by usage. Ultimately a final test will be made by storing cider in casks made of the woods which have given reasonably satisfactory results in the preliminary tests.

The ciders used were as follows :—

1. A blend : specific gravity 1.017, acidity 0.47%, tannin 0.20%.
2. A sharp cider : specific gravity 1.016, acidity 0.86%, tannin 0.13%.
3. A sweet cider : specific gravity 1.024, acidity 0.24%, tannin 0.16%.
4. A bittersweet cider : specific gravity 1.016, acidity 0.30%, tannin 0.44%.

Two pieces of wood of each sample, $4\frac{1}{2}$ in. by $\frac{1}{4}$ in. by $\frac{1}{4}$ in., were immersed in a pint bottle of each type of cider. Each treatment was quadruplicated, controls being left in each case. The treated ciders were stored in a cool place for six months, after which the effects of the various woods were examined. Unfortunately all the bittersweet samples developed ropiness and became useless for the purposes of the test.

Results.

The following notes serve to indicate the effect of each wood on the flavour and condition of the respective ciders :—

1. BLEND.

Wood.	*Remarks on Cider.*
Control	Perfect condition ; flavour good.
Prime Clear British Columbian Pine	Slightly cloudy ; paler than control ; strong pine wood flavour.
Siberian Red Fir (Redwood) ..	Bright ; slightly paler than control ; strong pine wood flavour.
Archangel White Fir ..	Bright ; slightly paler than control ; unpleasant woody flavour.
New Zealand Kauri Pine ..	Very cloudy ; paler than control ; resinous scum ; very potent unpleasant bitter flavour.
Louisiana Red Cypress.. ..	Bright ; very slightly paler than control ; slight alteration in flavour ; woody aftertaste.

2. SHARP CIDER.

Control	Bright ; fair condition ; clean.
Prime Clear British Columbian Pine	Bright ; very gassy ; slightly paler than control ; aromatic pine flavour.
Siberian Red Fir (Redwood) ..	Slightly cloudy ; pine flavour detected, less pronounced than previous sample.
Archangel White Fir	Slightly cloudy ; gassy ; slight woody flavour.
New Zealand Kauri Pine ..	Cloudy ; resinous froth ; very unpleasant bitter flavour.
Louisiana Red Cypress.. ..	Slightly cloudy ; slight woody flavour.

3. SWEET CIDER.

Control	Good ; fairly bright ; clean.
Prime Clear British Columbian Pine	Slightly cloudy ; slightly paler than control ; pronounced pine wood flavour.
Siberian Red Fir (Redwood) ..	Slightly cloudy ; slightly paler than control ; flavour of wood less pronounced than in previous sample.
Archangel White Fir	Slightly cloudy ; slightly paler than control ; woody flavour ; less affected than in two preceding samples.
New Zealand Kauri Pine ..	Cloudy ; very gassy ; resinous froth ; extremely bitter and unpleasant.
Louisiana Red Cypress.. ..	Slightly cloudy ; very gassy ; slight woody flavour.

In each case the control samples had kept satisfactorily. The effect on the flavour brought about by each particular wood was similar in character in each type of cider, although varying in intensity. The effects were on the whole most pronounced in the sweet cider and least pronounced in the sharp type. There was also some degree of variation in the condition and appearance of the different ciders due to the action of the particular wood. The acidity and the tannin value throughout did not vary from the controls, and in one case only was there a marked effect on the specific gravity. This was where the British Columbian Pine was immersed in the sharp cider.

Prime Clear British Columbian Pine brought about a very unpleasant flavour in the blend : in the sharp and sweet ciders the effects on the flavour were also very pronounced, while the alteration in the specific gravity of the sharp cider resulted in a very hard character.

Siberian Red Fir gave a strong pine flavour in the case of the blend, but the effect was much less marked in the sharp and the sweet ciders.

Archangel White Fir had less effect on the flavour of the cider than either of the former woods and in each type of cider it merely imparted a woody taste.

New Zealand Kauri Pine had the most marked effect upon the flavour of all three ciders. The extremely unpleasant harsh, bitter flavour which resulted from this wood made all the samples most objectionable to drink.

Louisiana Red Cypress affected the flavour of the cider least of any of the woods tested, but it had the effect of altering the flavour slightly in each case and of leaving a woody taste on the palate.

Conclusions.

None of the woods examined were without action on the flavour of any of the test ciders : and none appear of outstanding promise.

Of the individual woods tried, it is possible that Archangel White Fir and Louisiana Red Cypress may prove serviceable if some initial treatment can remove the woody flavour.

It is highly improbable that untreated New Zealand Kauri Pine will be of any service, and it is doubtful if either British Columbian Pine and Siberian Red Fir will meet requirements.

THE RÔLE OF PECTIN IN CIDER-MAKING PROCESSES.

I. INTRODUCTION AND HISTORICAL.

By VERNON L. S. CHARLEY.

INTRODUCTION.

The extremely complex composition of many of the classes of compounds that are present in the juice of apples and in the ciders made therefrom in many cases has prevented the application of specific chemical determinations to follow the various transformations and disintegrations undergone by such compounds as the pectins, tannins and proteins. Only as the empirical and structural compositions and the chemical properties of these compounds have been determined in the many academic researches undertaken throughout the world in recent years has it been possible to attempt to assess the ultimate effect of the compounds on the processing of raw fruit materials and on the final quality of their end products. The chemistry of the pectin constituents of fruits has only commenced to take definite shape in the last few years, and even until quite recently new formulae were being suggested. Nomenclature has been the cause of much confusion, and each school of thought has originated and urged its own terms. But in the past few years agreement in ideas has materialised, certain classes of definite pectic compounds have become recognised and, simultaneously, methods have been evolved for their estimation. With these methods available, it has been possible to commence a study of the rôle of pectic substances in cider making and their effect on the fermentation processes and on the clarity, flavour and stability of the resulting ciders.

The chemical relationship of pectins in the fermentation industries had not previously been studied until the French Oenological Stations commenced a collaborative investigation on the precise significance of pectin changes in fermenting and stored wines. The results were of such significance that, in view of the analogy between wine and cider-making practice, it was considered possible that similar influences would be exerted by pectin and its derivatives on the fermentation and flavour of apple juice and cider.

It has been usual to attribute many phenomena occurring in cider-making to the action of pectin, using this term in a wide sense, but only in few cases have attempts been made to study by quantitative methods some of the changes which have been assumed to be responsible for the various observed effects. In general, the alcohol precipitation method of estimation has been used, and the results so obtained do not point to the same conclusions as those derived from the more recent calcium pectate procedure of Carré and Haynes.

During the past two years, several disconnected cider problems have been under investigation at Long Ashton, and in each case the studies were extended to include the determination of pectin. The results of four of these experiments are presented in Part II of this series (This Report, p. 227).

HISTORICAL.

From the earliest times that cider has possessed a literature of its own, it has been recognised that certain viscous compounds were present which conferred a degree of " body " and viscosity on the juice. The term " mucilage " was used in the earlier periods, and this was succeeded by " pectosine " used in a similar sense. The Herefordshire Pomona contains the following paragraph: " The mucilage, or pectosine, when abundant, forms another element of distinction between good and bad juices. It renders the fresh juice more thick and viscous, and eventually gives softness, and body to the liquor. It helps also to preserve the alcohol by opposing the acetous fermentation and is thus always present in long keeping ciders and perries."

The first definite pronouncement concerning the importance of pectins in cider processes was contained in a progress report of the Long Ashton Cider Institute by Barker in 1910 (1), which dealt with the effects of maceration. It was there noted that maceration for long periods resulted in a low yield of juice on account of the difficulty encountered in its expression, It was suggested that this was due " to the mucilaginous and pectic elements of the tissues of the fruit, which, either as a result of chemical change or of their passage into a state of semi-solution, render the pulp more viscid and, therefore, more difficult to press dry." Further, in the same report, a connection between the mucilaginous compounds and clarification was indicated. It was thought possible that in the macerated juices the increases in the pectin content of the juice caused a more considerable subsequent flocculation during fermentation than in juices pressed straight from the mill; this clarification, by occluding in the coagulum a quantity of yeast material, effected by natural means a retardation of fermentation and might partly account for the high esteem in which, despite the many drawbacks of the method, the maceration process was held in past days.

Before proceeding to a brief discussion of the work which has been carried out on the pectin relationships in fruit and wines, it is desirable to appreciate, as far as is possible in the present state of knowledge the various classes of pectin compounds, their transformation and the factors which govern their decomposition.

Chemical Aspects of Pectic Compounds.*

Pectose, the parent substance, is a highly complex insoluble substance formed by the combination of cellulose and pectin. Pectose is contained in a large number of fruits, and is closely associated with the cell-wall material. Decomposition into cellulose and pectin is effected by the action of hydrolysing agents such as mineral acids and specific enzymes. Pectin is of great importance as it is the active principle in the formation of gels with sugar and acid, and it is the pectic compound that is held to confer viscosity on the fruit juices. Pectin itself is the methyl ester of pectic acid, and various hydrolysing agents and enzymes are capable of producing pectic acid from pectin with the simultaneous formation of methyl alcohol. The actual hydrolysis is not always so simple as this, for intermediate products are also formed in which a varying number of methyl groups are eliminated, but the end product is in all cases pectic acid, which possesses no gelling power but which is characterised by forming an insoluble calcium salt which can be used as a means of determining pectin in fruit solutions. The acids in the fruit are to some extent capable of effecting the progressive transformations of pectose and pectin into pectic acid, but probably a larger share of this change is due to enzymes which have specific effects on the various products.

Pectose is the substrate for pectosase, whilst pectin, pectinic and pectic acids are decomposed by pectosase and pectase into simpler compounds which include reducing sugars. It is not known how much of the total loss of pectin is due to enzymes occurring naturally in the fruit tissues or to the fermentative capacity of the yeast cells and their own specific enzymes, or indeed to the enzymes secreted by bacteria and moulds which may gain access to the juices. Some significance attaches to the observations (2) that have been made on pectin decomposition by enzymes secreted by moulds and bacteria. These enzymes appear to be similar to those found in normal plant tissues, and it is believed that the disintegration of fruit tissues which accompanies fungal diseases can be attributed to the series of changes in the pectic constituents effected by the secreted enzymes. It will be appreciated that chemical and enzymic reactions are possibly occurring simultaneously in the apple and the expressed juice, and the elucidation of the relative importance of each of these would seem to be of interest in order accurately to assess the various ways in which pectin changes are influenced by the nature and treatment of the fruits and their products.

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* Department of Scientific and Industrial Research. Food Investigation. Special Report No. 33. " A Critical and Historical Study of the Pectic Substances of Plants." 1929.

Pectic Changes in the Ripening Fruit.

The study of the chemical changes occurring during the normal ripening processes of the apple has recently been extended to include determinations of pectose and pectin in the tissues (2, 3, 4). As ripening proceeds, there is a progressive reduction in pectose and an almost corresponding increase in pectin content. Chemical and enzymic hydrolysis are presumed to be responsible for this, and simultaneously there is a slight removal of soluble pectin in the form of pectinic acids, which are further degradation products of the parent material. During the senescence period there is a decrease in the pectin figure, until at the death of the apple this constituent has almost entirely disapperared. If pectin is as essential in cider-making as Warcollier (quoted later) supposes, it becomes a matter of importance to press the apples at the correct stage of maturity ; pressing of immature apples will afford a low pectin content, the insoluble pectose being left in the tissues which comprise the pomace ; over-ripe fruit, also, will afford a juice in which the maximum possible percentage of pectin will not be reached on account of some decomposition having taken place. Before leaving the subject of the fruit, it is necessary to add that pears yield a juice which has always been supposed to contain larger quantities of pectin than apples. It is, however, known that pear juice is rich in pectase, and that during fermentation extremely heavy deposits of gelatinous material are thrown down. The high pectase content of pear juice has been utilised to induce clarification in ciders that are difficult to clear.

Pectin Changes during Fermentation.

The only data on changes in pectin content during fermentation refer to French wines. These indicate that considerable reductions in pectic compounds are effected :—

	Chasselas grapes. %	*Aramon grapes.* %
Pectic compounds before fermentation ..	0.2496	0.1175
Pectic compounds after fermentation ..	0.1480	0.0982

Influence of Pectin on Flavour.

Warcollier includes the following statement in his book, " Le Cidrerie " (5) : " Pectic materials are the substances which contribute richness and viscosity to the juice All high-class ciders contain these compounds, generally to the extent of 0.3—0.5 per cent. ; to them can be attributed the mellowness of the juice, a character different altogether from the sweetness afforded by sugar. It is impossible to indicate in what percentages pectic material should be present in apples to obtain eventually the best ciders, for the quantities of the pectic compounds in the fresh juice differ widely from those in the fermented cider. In the course of fermentation, especially during maceration and defecation, a coagulation and precipitation of part of the pectin compounds is affected, the extent of which cannot be estimated in advance. All that can be said in the present state of our knowledge is that pectic materials are essential constituents of a good juice, that they play important roles in the defecation or spontaneous clarification of the juices and that they should be present in all normally constituted ciders."

A relationship between softness and mellowness and the bouquet of wine has been suggested by Semichon (6). The bouquet appears to be closely associated with the dissociation of methyl pectate. Well authenticated effects of the methyl radical on essences obtained from various fruits have been observed. and the French workers suggest that the decomposition of pectin into pectic acid and methyl alcohol results in a further series of reactions between the latter product and the essences present in the fruit medium.

French Wine Research Stations have published many papers on the effect of pectin on wine-making and wines, culminating in the successful attempt to confer " moelleux " or " velouté " (softness, mellowness or " body ") on wines by a preliminary heating of the crushed fruit. Muntz and Lainé (7) had traced this property to the soluble pectin compounds, and it has been shewn subsequently that mellowness may be increased by the addition of 0.04 per cent. pectin to the wine. It is interesting to note that this character under consideration is very prominent in Sauternes, wines prepared from grapes gathered in a ripe condition, and in Grecian wines, where the practice is to warm part or all of the marc previous to pressing. In view of what has been said above on the chemical aspect of the pectin problems, it will be appreciated that the application of heat to the marc will convert some insoluble pectose into soluble pectin which latter compound is assumed to enhance the flavour and quality of the wine. The distribution of pectins in grapes is shewn by the following data :—

Skins	weighing	223	gms.	contained	1.190 gms.	pectin.
Interior (parenchyma) ..	,,	110	,,	,,	0.690 ,,	,,
Must	,,	667	,,	,,	0.720 ,,	,,
Total ..		1000			2.600	

The influence of pectin on flavour was discussed by the writer in a recent paper dealing with experiments on non-alcoholic apple juices (8) in which these were treated separately with germ-proof filtration, pasteurisation, and pectin decomposing enzymes. Direct correlation was indicated between the " body " of the juice and the calcium pectate figure. For the purpose of completeness, one section of the results are included here :—

EFFECT OF REMOVAL OF PECTIN ON FLAVOUR OF NON-ALCOHOLIC APPLE JUICE.

(Long Ashton Annual Report, p. 224, 1932).

Treatment of Juice.	*Method of Sterilisation.*	*Calcium pectate.* %	*Flavour.*
No enzyme added ..	Seitz filtration ..	0.0220	Fair but thin.
do. ..	Pasteurisation ..	0.0271	Good, full bodied
Enzyme added ..	Seitz filtration ..	0.0140	Fair.
do. ..	Pasteurisation ..	0.0235	Full bodied.

The enzyme used was Pectinol which has recently been used in America for the clarification of fresh apple juice. The data show that the Seitz filter removed a certain amount of pectin and this appeared to be reflected in the lack of body in the filtered juices. For the production of a non-alcoholic apple juice it is essential to effect some clarification before filtering the fresh juice, and it becomes a matter of considerable difficulty to decide between the respective merits of a process which affords easier filtration but results in a thin product which lacks fullness of flavour, and a process which leaves the pectin substantially unaffected, yielding a juice which is only filtered with difficulty, but which has a full flavour. Despite the attractive features of the procedure for completely removing the soluble pectin it is possible that when due regard is paid to the quality of the end product the process may not be so satisfactory as was originally supposed.

Pectin and Pasteurisation.

The use of mould secretions for the precipitation of pectin from fruit juices has been investigated by Kertesz, of the New York State Agricultural Research Station (9). This worker attributes the "cooked" taste acquired by fruit juices on being pasteurised to the effect of the fruit acids on the pectins. It was therefore claimed that removal of pectin from the fresh juice would allow a juice to be pasteurised without any danger of subsequent spoilage of flavour.

Enzyme Decomposition of Pectin.

Considerable use has been made in America of several enzymes which have been developed largely in connection with the production of non-alcoholic juices. The enzymes are obtained by growing various moulds on a physiological salt solution containing sugar and pectin, and are fixed on materials such as bran or pollards and sold either in this form or as a water solution. Very interesting results have been obtained with one of these enzyme preparations at Long Ashton (10) but, in view of the considerable loss of pectin occasioned by the enzyme, there may be danger of flavour impairment. It has been noticed that there is evidence of the continuation of enzyme action after the juices have been removed from the solid base and filtered. Unless this can be prevented, it will constitute a serious drawback to the method.

"Dropping Bright."

Several well-known phenomena in cider-making practice have been attributed to pectin changes. One of these is "dropping bright" (11), in which a cider or perry which is difficult to clear to a satisfactory degree, will deposit, when conditions are favourable, a heavy coagulum, leaving the liquor in a brilliant state.

Mainly from analogy with somewhat similar pectin changes in other plant juices, Barker concluded that the important factor was pectase which converted the soluble pectins into an insoluble gelatinous form. This enzyme appeared to act only in neutral or slightly acid media. Confirmation for this view was found in two experimental results. If crude pectin extracts obtained from apple pomace were completely neutralised with calcium carbonate, the addition of a small volume of freshly pressed apple juice or pomace caused the former to set to a firm jelly within 24 hours at 25°C. Similarly, the addition of limited quantities of such extracts to freshly pressed apple juices produced " dropping bright " in the latter when the acidity was sufficiently reduced.

In the case of perry, the removal of this milkiness by the deposition of a most voluminous precipitate has more than a visual significance, for the flavour of the clarified beverage is vastly improved, and it would constitute a valuable addition to our knowledge of clarification methods if the precise nature of this phenomenon could be accurately determined, and a means discovered by which a similar withdrawal of deposit could be induced in ciders and perries which stubbornly resist clarification.

Deposits in Bottled Ciders.

A further matter, and one which, equally with that of flavour, provided the incentive to commence the present investigation, is the so-called pectin deposit which appears in characteristic flocculent form in pulp-filtered ciders at varying periods after bottling. The white material is often difficult to distinguish by eye from yeast deposit, but unlike this type, the pectin is flocculent, and does not form a compact layer as is the case with yeast. This question is included for study in the investigations on bottled ciders by Barker and Grove (12). The following generalisation was then made : " The insoluble matter deposited from bottled cider during storage consists mainly of pectin derivatives which settle out in loose and flocculent form. Most of this material is thrown out during the fermentation of the juice and in the early life of the cider. The age of the cider at the time of bottling is thus important in this connection. The other factor that can be definitely associated with the results is the acidity. Low acid ciders, especially those with less than 0.4 per cent. malic acid, are much more commonly subject to this type of deposit than those of higher acidity."

The following abridged table illustrates the nature of their results obtained on bottled ciders when alcohol precipitates were determined :—

After Barker and Grove (12).

Variety.	*Alcohol precipitate per cent.*	
	At bottling, 9.3.22.	10 *months later,* 1.1.23.
Backwell Red	0.55	0.58
Butter Box	0.23	0.29
Crimson King	0.29	0.36
New Foxwhelp	0.29	0.22
Kingston Black	0.25	0.24
Royal Wilding	0.40	0.38
Mixed Fruit	0.42	0.48

The data were obtained by weighing the amount of dried precipitate produced on addition of two volumes of absolute alcohol to one volume of cider. Although the results show no definite trend in the figures, there is a tendency for the majority of the percentages to increase in bottle. This cannot be at the expense of pectose, for no insoluble material was present in the original bottled material. These data cannot be satisfactorily interpreted in the light of our present knowledge of pectin derivatives.

Pectin in Pomace.

Finally, brief consideration should be given to the pectin which remains in the pomace after the juice has been pressed out. A mixture of pectose and pectin is present, and when the material has been dried to 10 per cent. moisture, a simple water extraction and alcohol precipitation will afford 10-15 per cent. of crude pectin. In commercial procedure it is usual to hydrolyse the pectose by an organic acid solution and thus to exhaust completely the dried material from pectic material. It is said that a preliminary extraction with large volumes of cold water will remove a form of water-soluble pectin which has no gelling powers, and this practice is widely adopted.

Analysis of Pectin Derivatives.

The general method for determining the pectin content of juices, etc., was, until recently, that which depended on precipitation with excess of alcohol. It is certain that other compounds are thrown out of solution and high results are always obtained with this method when compared with the pectin contents given by the calcium pectate method of Carré and Haynes. In this latter procedure, sodium hydroxide is employed to hydrolyse the various pectin compounds in the solution into pectic acid. Sodium pectate is formed, and on acidification with acetic acid the pectic acid is precipitated as the calcium salt by the addition of calcium chloride. Results are usually expressed as calcium pectate.

Complications arise in the case of analyses of fermented products on account of the apparent production of gummy substances which are liable to be brought down with the pectin in the alcohol precipitation method. Semichon and Flanzy (6) add 1 per cent. of hydrochloric acid to the wine before precipitation with alcohol. The coagulum is dissolved in water, and the soluble pectin separated as calcium pectate. The filtrate can be treated with alcohol to reprecipitate the gum.

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THE RÔLE OF PECTIN IN CIDER-MAKING PROCESSES.

II. PECTIN CHANGES ASSOCIATED WITH MACERATION AND FERMENTATION, AND THE EFFECTS OF THE ADDITION OF PECTIN SOLUTIONS TO DRY CIDERS.

By VERNON L. S. CHARLEY.

The preliminary part of this paper (this Report, page 217) indicated the general scope of the present series of investigations, and gave a brief account of some of the relevant research work, dealing chiefly with pectin studies in wine-making that had been accomplished.

In this, the second contribution to the series, the following four experiments, disconnected except in so far as pectin was the salient feature of interest in each, are discussed in detail :—

A. Pectin changes during maceration and subsequent fermentation.
B. Loss of pectin during normal fermentation.
C. Loss of pectin during fermentation with pure yeast cultures in pasteurised and Seitz filtered apple juices.
D. Addition of pectin solutions to dry ciders.

EXPERIMENTAL.

A. Pectin Changes during Maceration and Subsequent Fermentation.

For this experiment six gallons of fresh Bramley's Seedling juice were used (analysis : specific gravity 1.040, acidity 0.98 per cent., tannin 0.15 per cent.). The pomace which was macerated with this culinary juice was taken from a bulk of once-pressed material from the ciderhouse. 1 kg. of the pomace on being subjected to extremely heavy pressure yielded 230 cc. of a syrupy juice with the following analysis: specific gravity 1.070, acidity 0.61 per cent., tannin 0.05 per cent.

Twenty beakers, divided into two series, each contained 250 gms. of pomace. In one series 600 cc. of Bramley's Seedling juice was added to each beaker, the parallel series each receiving a similar quantity of water. The juice and water were quickly incorporated with all the separate pomace samples by vigorous stirring, and after 1 minute the first lot of pomace in each series was pressed out and the expressed juice or aqueous extract analysed. At various periods during the next three days of maceration further separate portions were pressed out and the juices and extracts examined. The volume of liquid collected was measured and its specific gravity determined at 15.5°C. by a specific gravity bottle. Acidity and tannin estimations were effected in the usual way and pectin determined by the calcium pectate method of Carré and Haynes (1).

The results are shown in Table I.

TABLE I.

Changes in Pectin and Other Constituents During Maceration.

Experiment. No.	Length of Maceration in hours.	Juice Expressed ccs.	Specific Gravity of Juice.	Acidity per cent.	Tannin per cent.	Calcium Pectate per cent.
C.1	0 (Control)	650	1.0538	0.83	0.12	0.227
C.2	½	660	1.0543	0.80	0.08	0.238
C.3	1	600	1.0545	0.82	0.08	0.243
C.4	2	660	1.0567	0.84	0.09	0.245
C.5	4	660	1.0551	0.83	0.08	0.290
C.6	6	670	1.0560	0.86	0.08	0.298
C.7	11	650	1.0554	0.90	0.08	0.298
C.8	24	655	1.0536	0.98	0.08	0.300
C.9	48	640	1.0511	1.00	0.09	0.289
C.10	72	620	1.0458	0.98	0.08	0.270
W.1	0	650	1.0133	0.12	0.005	0.170
W.2	½	650	1.0154	0.12	0.005	0.177
W.3	1	655	1.0157	0.12	0.005	0.187
W.4	2	650	1.0163	0.14	0.007	0.202
W.5	4	650	1.0181	0.16	0.009	0.236
W.6	6	645	1.0169	0.17	0.008	0.259
W.7	11	640	1.0169	0.22	0.010	0.301
W.8	24	645	1.0169	0.23	0.010	0.309
W.9	48	645	1.0143	0.23	0.011	0.289
W.10	72	640	1.0115	0.35	0.011	0.257

There is a tendency for the amount of juice recovered by the pressings of the macerated material to rise until six hours after the commencement, but beyond this there is a distinct loss of expressed juice. The specific gravity rises until about 6 hours of maceration has been reached, but a decrease is then experienced, due to fermentation which was visibly commencing at the 11-hour period. Acidities show definite increases, noticeably in the water maceration. In view of the fact that a juice with 0.15 per cent. tannin was being macerated with a pomace which had yielded a juice with 0.25 per cent. tannin, it is surprising to note that the tannin figures are so low. It must be presumed that oxidation and precipitation of tannin is being effected, and that some of the tannin from the Bramley's Seedling juice is being fixed on the pomace itself. This loss of tannin is of interest in view of the fact that maceration of bittersweet pomace with the juice from culinary or sweet cider varieties has always been advocated with a view to increasing the " body " by means of raising the tannin content.* In view of the failure of the data afforded by the permanganate reducing figure to explain the changes in flavour associated with the maceration process, it is interesting to note that the pectin contents of the expressed juices do show considerable differences. With the cider addition series, maceration during 24 hours had effected an increase of about 30 per cent. in the pectin in the juice, whilst with the water series, there had been an actual increase of 80 per cent. in the pectin over that of the control. Such data taken by themselves would appear to indicate a possible solution to the problem of what actually happens during maceration to impart a mellow, full flavour to the cider. But the following experiments throw some doubt on the pectin being as important as might be expected from a mere consideration of the data in Table I.

The expressed juices from the cider and water maceration series, *i.e.* C. 1-10 and W. 1-10, were immediately placed in sterilised flasks which were closed with fermentation locks and maintained at room temperature. The cider juices were examined from time to time for gravity and condition ; at a gravity of about 1.015, the juices in the cider series were filtered through a clarifying filter pad into bottles and were retained for analysis. Each individual sample in the series C. 1-8 contained only the merest traces of pectin. Precipitates were obtained with C. 9 and C. 10, but were not sufficient to weigh. The juices all contained heavy gelatinous deposits.

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* The possibility that the amelioration in flavour caused by maceration is due to the oxidized form of tannin is mentioned elsewhere in this Report. See Pickford, P. T. H. " Experiments on the Improvement of the Juice from Culinary and Dessert Apples by Maceration with Pressed Bittersweet Pomace. Progress Report II." This Report p. 209.

The water maceration series gave similar results. In this case the gradual formation of the gelatinous deposit was observed with ease, on account of the almost colourless nature of the extract. During the fermentation the characteristic *B. xylinum* film was formed in the flasks, indicative of the dangers that juices are exposed to during this macerating process, for only during that period could the juice have become inoculated.

The gravities and flavour characters of the various ciders in the series during and subsequent to this fermenting period in bottle are of some interest.

There appears to be a tendency for increasing length of maceration, under the conditions of the experiments to retard fermentation to a slight degree. (The highest gravity 10 days after commencement of fermentation was that of C. 7.) Changes in flavour were not discernible in the ciders from macerations up to four hours duration, but those of six and eleven hours afforded ciders which were quite definitely softer in flavour than the control. Macerations of 24 hours or more introduced a rather harsh flavour, but the underlying fullness of character was also present.

The results are not possible of exact interpretation at this stage. They indicate that during maceration there is a considerable increase of soluble pectin in the expressed juice, but this pectin is largely removed during subsequent fermentation. The flavour differences cannot therefore be correlated with the presence of soluble pectin, and unless degradation products of pectin can be shown to have an ameliorating effect on the flavour of ciders, it would seem that the flavour changes noted in these experiments must be attributed to other causes.

B. Loss of Pectin during Normal Fermentation of Apple Juice.

A series of casks of fresh juices made from single varieties of cider apples were used for this experiment, and samples taken from a central point in the cask at definite intervals. The casks were stored in the ciderhouse under the normal conditions prevailing there and were mostly 120 gallons in capacity. The 200 cc. samples taken from the middle of the casks were filtered through coarse filter paper to remove solid particles of tissue and skin, and the pectin was determined by the use of Carré and Haynes calcium pectate method. Two series of juices were selected, one early in the season, September, and the other at the end of November. The data are presented in Table III.

TABLE II.

GRAVITY AND FLAVOUR CHANGES IN CIDERS MADE FROM JUICES MACERATED FOR DIFFERENT PERIODS.

	Control.	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8	C.9	C.10
Length of maceration in hours	–	0	½	1	2	4	6	11	24	48	72
Gravity of freshly expressed juice ..	1.040	1.054	1.054	1.055	1.057	1.055	1.056	1.055	1.054	1.051	1.048
Gravity of juice after 2 days	1.038	1.028	1.031	1.032	1.032	1.032	1.032	1.034	1.034	1.035	1.035
Gravity of juice after 10 days	1.033	1.023	1.025	1.025	1.025	1.026	1.026	1.030	1.027	1.028	1.028
Flavour after 3 weeks in bottle	Thin and rough.	Same as Control.	Same as Control.	Same as Control.	Same as Control.	Same as Control.	Slightly softer & fuller than Control.	Definitely softer & fuller than Control.	Same as 7 but harsh character present	Same as 8	Same as 8

TABLE III.

Loss of Soluble Pectin During Normal Fermentation of Apple Juice.

Variety of Apple.	Analysis of Fresh Juice.					Calcium Pectate per cent. in Fermenting Juices.			
	Specific Gravity.	Acidity %	Tannin %	Date of Pressing.	Calcium Pectate % in fresh juice.	After 5 days.	After 14 days.	After 23 days.	After 6 months in bottle.
Early Season.									
Sour Natural	1.056	0.45	0.16	31.10.33	0.0988	0.0781	0.0512*	Trace	—
Improved Pound	1.061	0.23	0.15	do.	0.0574	0.0510	0.0382*	Trace	—
Hangdown	1.061	0.16	0.19	do.	0.1780	0.1107	Trace*	—	—
Blumen	1.054	0.26	0.19	do.	0.1416	0.0721	Trace*	—	—
Knotted Kernel	1.074	0.23	0.33	do.	0.1302	0.0721	Trace*	—	—
Late Season.									
Sharp.									
Kingston Black	1.067	0.72	0.23	27.11.33	0.0924	0.0573	0.0201	—	Trace
do.	1.063	0.72	0.21	do.	0.0444	0.0219	Trace	—	Nil.
Woolston Spice	1.045	0.46	0.13	do.	0.0552	0.0456	0.0252	—	—
Barn Door	1.062	0.83	0.28	do.	0.0446	0.0432	0.0228	—	—
Layne's Colonels	1.060	0.75	0.22	do.	0.0600	0.0510	0.0264	—	—
White Bache	1.061	0.77	0.18	28.11.33	0.0704	—	0.0160	0.0139	—
Normington	1.064	0.47	0.34	do.	0.0832	—	0.0156	0.0143	—
Lambrook Pippin	1.066	0.62	0.32	do.	0.0688	0.0480	0.0156	0.0143	Trace
White Sharp	1.058	0.64	0.17	29.11.33	0.0592	—	0.0190	0.0100	—
Sweet.									
Woodbine	1.053	0.18	0.13	27.11.33	0.0920	0.0556	Trace.	—	—
Woodbine (Kittisford)	1.069	0.34	0.20	30.11.33	0.1096	—	0.0473	0.0413	0.0237
Smith's Sweet	1.066	0.26	0.19	27.11.33	0.0640	0.0480	0.0164	0.0154	Trace
Sweet Coppin	1.050	0.28	0.13	do.	0.0840	0.0630	0.0506	0.0381	0.0101
Doux Amer	1.046	0.28	0.19	29.11.33	0.0488	0.0168	0.0108	—	Trace
Bittersweet.									
Harry Master's Jersey	1.060	0.25	0.23	27.11.33	0.0744	0.0148	Trace	—	—
Green Bittersweet	1.062	0.22	0.21	do.	0.0704	0.0332	0.0304	0.0101	—
Sweet Clusters	1.060	0.20	0.20	do.	0.0784	0.0504	0.0268	—	—
Shrawley Bittersweet	1.067	0.32	0.48	do.	0.1040	0.0988	0.0452	0.0314	Trace
Slack-ma-Girdle	1.062	0.27	0.20	do.	0.0628	0.0396	0.0196	—	—
Michelin	1.047	0.22	0.24	29.11.33	0.0584	—	0.0150	0.0138	Nil
Tardive Forestier	1.053	0.28	0.37	do.	0.0652	—	0.0208	—	—
Frequin	1.047	0.24	0.43	do.	0.0224	—	0.0104	0.0102	—
Harry Master's Jersey	1.052	0.22	0.27	do.	0.0516	—	0.0396	—	Trace

* Indicates Calcium Pectate after 9 days only.

The highest figures for pectin in the fresh juices occur in the earlier varieties, Hangdown, Blumen, and Knotted Kernel. The later Woodbine juice which contained 0.1096 per cent. calcium pectate comes from a Somerset orchard which invariably affords heavy fully-flavoured ciders.

From a chemical point of view it is difficult to associate this high value in the earlier juices with maturity or otherwise of the fruit, as a close watch is exercised on all the lots of fruit previous to milling, and the varieties are all taken to the mill at approximately similar states of maturity. It is probably a varietal effect.

In general, no definite correlation can be found between the specific gravity of the juice and the pectin content. For example, the Improved Pound and Hangdown juices with equal gravities gave 0.0574 per cent. and 0.1780 per cent. of calcium pectate respectively. The highest value was obtained with Hangdown, which is an apple used in Somerset to blend with Kingston Black. It is of interest to note that, whilst the pectin content in the first Kingston Black juice is approximately the same as that for the Somerset Woodbine, and is considerably higher than that of the other varieties milled at the same period, the second juice afforded only half as much calcium pectate.

Turning next to the rate of decomposition of the soluble pectin in the fermenting juices, the data show that this is rapid, and that many juices have only small quantities of soluble pectin left after a fortnight of fermentation. The loss of soluble pectin from the three juices, Hangdown, Blumen, and Knotted Kernel, which gave relatively high proportions of calcium pectate in the fresh juice, was especially rapid and only traces were found after 14 days. On the other hand, in a few juices, for example Kingston Black, Lambrook Pippin, Smith's Sweet, Doux Amer, Shrawley Bittersweet and Harry Master's Jersey (from the Long Ashton orchard), a trace of calcium pectate was obtained from ciders filtered into bottle and stored for 6 months. The Woodbine cider to which allusion has previously been made gave a slight but weighable precipitate (0.0237 per cent.), and Sweet Coppin, with an initial content of 0.0840 per cent. still retained 0.0101 per cent. after a similar period in bottle. These figures are very low and it seems doubtful whether soluble pectin compounds included in the calcium pectate analysis can be of any considerable importance from the flavour point of view. The method used for the determination of the pectin is presumed to convert all soluble forms of pectin into pectic acid previous to the precipitation of the acid derivative as calcium pectate. The question arises as to the exact nature of the pectin decomposition and the degradation products. Any pectic acid that would be formed from the fully methoxylated pectin would be included by the calcium pectate method, and if that were the only product of the breakdown of pectin no appreciable change in calcium pectate percentage would be expected. It is possible that far-reaching disintegration of the pectin molecule is taking place, but simpler products have not yet been isolated.

Several points of chemical interest have arisen during the actual experimental work. In the first place, the calcium pectate precipitates were coloured according to the tannin content of the juice. Those from the sharp juices were practically colourless and required extremely careful manipulation during the prolonged washing with boiling water needed to remove the excess calcium chloride used as precipitant. The sweet juices, which usually have appreciably more tannin than the pure sharp varieties, gave precipitates which were light brown in colour, whilst the bittersweet precipitates were deep red—the colour being firmly associated with the deposit and persisting throughout the determination despite the very thorough washing.

Secondly, the physical nature of the calcium pectate deposit altered progressively as fermentation proceeded. The fresh juice precipitate was in every case gelatinous, closely resembling an alcohol precipitate of pectin. When the calcium pectate figure reached about 0.025 per cent., a significant change was noticed, for the precipitates gradually became somewhat amorphous and difficult to wash from the beaker, or again, later in the analytical procedure, from the filter paper. Towards the end of the fermentation when the precipitate was becoming very small, 100 ccs. of cider was used for each determination, but satisfactory duplication of figures was difficult, and it was often impossible to wash the precipitate completely from the filter paper into the beaker for transference to the Gooch crucible. No explanation can be offered at present for this change in physical condition of the precipitate.

Finally, it was observed that in several cases precipitates were obtained immediately on the acidification of the pectin solution which had been hydrolysed for 12 hours with sodium hydroxide. That the precipitate was pectin in some form was shown by the fact that, on filtering off the deposit and adding the calcium chloride reagent to the filtrate, no further precipitate was formed. The results were reproducible, and it is possible that some juices may contain sufficient calcium to precipitate the calcium pectate.

Alcohol Precipitate.

The calcium pectate method of determining pectin was chosen on account of its specific nature, for there is no doubt that excess alcohol precipitates compounds other than pectin (for instance, some nitrogenous materials are insoluble). But in the case of a few fresh juices the alcohol method was examined to discover in what way it differed from that of Carré and Haynes. The official American method (2) was found to be unsuitable. By this procedure the apple juice was evaporated to one fourth of its bulk and then precipitated with excess alcohol. In every case that this method was adopted a gummy deposit was obtained which was not homogeneous, and whose estimation presented many difficulties in manipulation. In consequence of this, the unevaporated cider was treated with excess alcohol (4 volumes), and the precipitate weighed after having been re-dissolved and again precipitated. The solution of the original precipitate and its re-precipitation resulted in a very considerable loss of bulk in the deposit. The data below are for fresh juices.

	Hangdown.	*Knotted Kernel.*	*Kingston Black.*
Calcium pectate % ..	0.1780	0.1302	0.0444
Alcohol precipitate %	0.2349	0.2715	0.1960

In a series of juices fermenting in the laboratory for another experiment, qualitative alcohol precipitations were carried out during the course of fermentation. After 10—14 days the copious precipitate so obtained diminished in quantity and in the later stages of fermentation the white flocculent material, whilst always present, was slight in bulk.

A Kingston Black juice was examined during its fermentation by the two methods and gave the following data :—

	Fresh Juice.	*After 5 days.*	*After 14 days.*
Calcium pectate % ..	0.0444	0.0219	Trace.
Alcohol precipitate %	0.1960	0.0800	0.0399

In France, the alcohol precipitate method, or a later modification with acid alcohol for dilute pectin solutions, is being used, but even the use of this method does not explain the wide differences between the pectin figures given by Warcollier (0.3—0.5 per cent.) for good ciders (3), and those indicated in this Report from English varieties, especially as the season during which the fruit was ripening was hot and dry, and the ciders were full bodied. It is obvious that knowledge of the more exact constitution of the alcohol precipitate is of importance, and this phase of the investigation is being continued.

C. Loss of Pectin in Seitz Filtered and Pasteurised Apple Juices Fermented with Pure Yeast Cultures.

The data presented in the previous section indicates the very complete removal of soluble pectin from apple juices fermenting in casks in the ordinary way. In order to distinguish between the chemical and enzyme actions in decomposing soluble pectin, an experiment was initiated in which one of two series of juices was subjected to heat ; the pectin in the unpasteurised series would thus be liable to be hydrolysed both by chemical and enzymic agents, whilst in the pasteurised series it was presumed that enzyme action would be completely suppressed.

One cwt. of King Edward VII apples were milled and pressed on 2nd January, 1935, and the juice immediately pulp filtered. The clarified juice was then passed through the germ-proof filter and the sterile liquid received in twenty 1-litre Erlenmeyer flasks, which had previously been autoclaved. 600 cc. of sterile juice were received in each flask, and ten of these were then pasteurised for half an hour at 100°C. The colour deepened to a rich gold, but no deposit was formed. When these vessels were cool, the juices, one from each series, Seitz filtered alone and Seitz filtered + pasteurised, were inoculated with 2.5 cc. of ten different active pure yeast cultures. The flasks had been closed with the usual aseptic cotton wool plugs, and these were flamed before and after inoculation, and again later throughout the various withdrawals of liquor which were made. The flasks were placed in a 25°C. incubator for 36 hours to start fermentation, and after this the fermenting juices were all retained at a steady temperature of 17°C. throughout the duration of the experiment. The natural yeast inoculation was obtained by a similar addition of the original untreated fresh juice to the two appropriate flasks.

The fermentation and calcium pectate data are given in Tables IV and V.

TABLE IV.

Changes in Soluble Pectin During Fermentation of Seitz-Filtered and Pasteurised Juices with Pure Yeast Cultures.

S = Seitz filtered only.
S + P = Seitz filtered + pasteurised.

Yeast Identification.	Source of Yeast.	Treatment of Juice.	Calcium pectate % in fermenting juices. (Calcium pectate before inoculation = 0.160%).			
			After 10 days.	After 24 days.	After 34 days.	After 50 days.
5	Yellow Styre cider ..	S	0.159	0.151*	0.129	0.103
		S + P	0.159	0.160*	0.161	0.165
9	Sweet Alford cider ..	S	0.152	0.137	0.101*	0.060
		S + P	0.160	0.160	0.159*	0.161
19	Strawberry Norman Cider	S	0.160	0.135	0.100*	0.057
		S + P	0.160	0.156	0.156*	0.156
34	Portuguese wine (Laureiro) ..	S	0.140	0.139*	0.136	0.117
		S + P	0.158	0.157*	0.157	0.158
37	Reisling wine ..	S	0.154	0.140	0.125*	0.094
		S + P	0.160	0.159	0.159*	0.162
41	Danish wine yeast used for apple wine ..	S	0.155	0.155	0.136*	0.106
		S + P	0.157	0.158	0.158*	0.158
45	Port wine	S	0.154	0.141	0.135*	0.096
		S + P	0.159	0.159	0.156*	0.158
B	English Brewer's bottom yeast ..	S	0.152	0.119†	Trace*	Nil.
		S + P	0.159	0.159	0.161*	0.160
N	Fresh apple juice ..	S	0.153	0.146	0.121*	0.106
		S + P	0.156	0.156	0.161*	0.160

* Indicates completion of fermentation (gravity = 1.000).
† Indicates commencement of mould growth.

TABLE V.

Changes in Specific Gravity During Fermentation of Apple Juice with Pure Yeast Cultures.

Original gravity of juice = 1.038.

Yeast Identification.	Treatment of Juice.	Specific gravity.			
		After 5 days.	After 10 days.	After 14 days.	After 24 days.
5	S	1.029	1.018	1.018	1.000
	S + P	1.035	1.031	1.025	1.000
9	S	1.034	1.027	1.023	1.002
	S + P	1.035	1.030	1.026	1.005
19	S	1.029	1.021	1.011	1.001
	S + P	1.033	1.024	1.015	1.002
34	S	1.027	1.019	1.014	1.000
	S + P	1.033	1.025	1.021	1.000
37	S	1.032	1.023	1.019	1.001
	S + P	1.037	1.029	1.025	1.001
41	S	1.029	1.019	1.010	1.001
	S + P	1.034	1.029	1.026	1.003
45	S	1.032	1.024	1.017	1.004
	S + P	1.033	1.026	1.022	1.003
B	S	1.037	1.031	1.029	1.011
	S + P	1.033	1.025	1.022	1.004
N	S	1.027	1.020	1.015	1.005
	S + P	1.030	1.019	1.012	1.006

N.B.—After 34 days the gravities of all samples were 1.000 or less.

The significant features of the above series of experiments may be summarised as follows :—

(*a*) The pectin content of the original Seitz-filtered juice was abnormally high.

(*b*) No loss of pectin was observed in the pasteurised series.

(*c*) A slow steady decomposition of pectin occurred in the Seitz-filtered juices in the case of all the yeasts used, this action continuing long after the cessation of fermentation.

(*d*) The pectin was decomposed to differing extents in the unpasteurised samples.

These points will now be dealt with in detail :—

(*a*) The high pectin content of the original juice is probably a varietal character. The fruits were acid and were milled slightly before complete maturity. Culinary apples have often been observed to give high pectin figures, and fruit used in this experiment had been stored under good conditions, and were free from fungal or other infections. The high pectin content of culinary apples in itself constitutes a difficulty in correlating pectin content with flavour, for despite their comparative richness in these compounds, ciders made from this type of apple are generally characterised by thin and rather harsh flavours.

(*b*) The stability of the pectin materials in the series which was pasteurised previous to inoculation with yeasts indicates that neither the chemical constituents of the juice nor the yeasts themselves or their associated enzymes were capable, under the conditions of the experiment, of disintegrating the pectin molecule. There is the possibility, however, that the pectin had been decomposed into pectic acid and methyl alcohol. The pectic acid would be included in the calcium pectate figure, and the only interpretation that can justifiably be placed on the data is that the total soluble pectic materials are not reduced in the pasteurised series.

The tendency noted in Samples S + P. 5, 9 and 37, for the calcium pectate content to increase in relation to the original figure is most probably explained by the fact that in these samples the amounts of liquor remaining for the last two determinations were small, and it was impossible to remove completely all the finely divided particles from the deposit, which became disturbed during the decantation.

The data are repeated with considerable regularity throughout the various yeast treatments and the four successive samplings, and this accumulative evidence definitely indicates that in the pasteurised juice series the added pure cultures of yeasts have not had any appreciable effect on the total soluble pectin content of the media.

(*c* & *d*) But the action of the yeasts and their enzymes cannot be similarly dissociated from pectin disintegration in the series that was merely Seitz-filtered. A slow and steady loss in calcium pectate was found, this loss extending well beyond the completion of fermentation. If the assumption is made that the pure yeasts do not affect pectin under any conditions, then the observed decomposition of pectin in the Seitz-filtered series must be attributed to the enzymes or acids natural to the juice which would not be removed by the germ-proof disc. In this case, the decomposition of pectin would be expected to be identical in all cases, as the various treatments were effected on exactly similar samples of juices taken from a well mixed bulk. But the data show that in each of the various yeast samples the residual pectin is present in quite different proportions. Hence it would appear that some other factor besides the natural enzymes of the juice is having an effect. Until fresh data are obtained from other series of experiments it is impossible to throw any clear light on these reactions, but it is possible that the yeasts contain agents which are capable of removing pectin from solutions only when some accessory factor is also present. This would be analogous to the well known enzyme and co-enzyme relationship which exists in baker's and brewer's yeasts. The pasteurisation process, viewed in the light of this suggestion, must be assumed to eliminate the accessory factor, with the consequence that the pectin is unaffected. In the presence of this essential factor, however, *i.e.* in the Seitz-filtered series, the yeasts must be considered to possess their own specific power of hydrolysing the pectins, as indicated by the differing rates of decomposition shown in Table IV.

A further possible explanation is that some yeasts are accompanied by inhibitors which prevent them from disintegrating the pectin molecules. This may be regarded as the reverse effect to that of the co-enzyme. The data obtained give no indication as to which, if either, of the phenomena are responsible.

Turning to the actual percentages of pectin left in the fermented juices, it will be seen that the two lowest figures are both given by cider yeasts (Sweet Alford and Strawberry Norman), whilst the highest residual amount is found in the juice fermented with Laureiro yeast. An interesting observation was made in the case of the brewer's yeast sample. This was similar to the rest of the series in appearance and analysis until 21 days after inoculation. At this period three small green mould colonies were observed on the surface of the fermenting juice, and these developed with rapidity until, by the 30th day, there was a complete film of mould covering the liquid. In view of the known effects of moulds on decomposing pectin aggregates it appears that the complete loss of soluble pectin occurring in this sample can be correlated with the presence of the mould infection.

With reference to the percentage removal of pectin, it is obvious by referring to Tables III and IV that more pectin remained in the juices in this series of experiments than in the ciders made in casks. Conditions, however, were widely dissimilar, for the cask materials consisted of fresh, untreated apple juices, whereas in these experiments with special yeasts the juice was pulp- and Seitz-filtered before inoculation with yeasts ; in the latter experiments, about 60 per cent. of the total original pectin was lost.

The whole series of flasks were examined daily with the intention of following any visual signs of pectin changes. Very little of significance was seen, except in the case of the Seitz-filtered juice fermented with yeast No. 34 (Laureiro Port Wine yeast). Immediately fermentation commenced, a white haze was noticed just beneath the surface. After 4 days this had become a definite white gelatinous deposit, for which no parallel was found in either series. As fermentation became more violent, the gelatinous deposit was dispersed and the final nature and appearance of the yeast deposit afforded no indications of this earlier phenomenon.

D. Addition of Pectin Solutions to Dry Ciders.

A further aspect of the rôle played by pectin in cider processing was studied when a series of experiments were carried out to investigate the possibility of using apple pomace extracts and citrus pectin for sweetening dry ciders. In the commercial pectin extraction process, a considerable volume of cold water is percolated through the pomace to remove cold water-soluble pectins (which do not play any part in the gelling process), together with sugars and colouring matter. The resulting solution is very dilute, but on concentration can be obtained at a gravity of 1.060, or about 15 per cent. sugar. Such a solution may contain 3 per cent. of crude pectin (by alcohol precipitation), and it was during an attempt to determine whether any good purpose would be served by such an addition to dry ciders that some interesting observations were made on the bottled samples.

A dry cider of poor quality was chosen for the experiments and was treated with cold and hot water pomace extracts, pure cane sugar, and finally, citrus pectin and sugar together, according to the following scheme :—

(1) **Pomace Extracts.**

600 gms. of dried apple pomace were soaked with 3,500 cc. cold water for 48 hours. The pomace was pressed and a juice of gravity 1.010 was obtained. This extract was evaporated at 35°C. in vacuo to a gravity of 1.055. At this concentration the extract contained 3.05 per cent. crude pectin. The residue from the cold water extraction was boiled with 3000 cc. water for one hour, and the extract evaporated to 1200 cc. (crude pectin = 3.27 per cent., specific gravity = 1.017).

Four litres of dry cider were mixed with 560 cc. cold water extract and the resulting gravity raised to 1.030 with cane sugar. Similar quantities of cider were respectively treated with 600 cc. hot water extract, and in the last case with sufficient sugar alone to raise the gravity to 1.030. The mixtures were thoroughly stirred and passed through a small pulp filter. One half of the clear cider was passed through a Seitz-clarifying pad, and bottled direct from the filter into screw stopper bottles, whilst the remainder was filtered through the Seitz germ-proofing pad, and bottled into sterile containers.

(2) **Citrus Pectin.**

Five gms. citrus pectin were mixed with a small amount of sugar and dissolved in 250 cc. water, the solution being strained through muslin to remove undissolved particles of pectin. The same dry cider as was used in the first part of these experiments was sweetened with sugar to a gravity of 1.015, and the following additions made :—

(*a*) 2 litres cider + 30 cc. pectin solution (= addition of approx : 0.03 per cent. pectin).

(*b*) 2 litres cider + 80 cc. pectin solution (= addition of approx: 0.08 per cent. pectin).

(*c*) ,, ,, ,, +140 cc. pectin solution (= addition of approx: 0.14 per cent. pectin).

(*d*) Control: no pectin added.

The solutions after thorough mixing were pulp filtered and then clarified. None, however, were passed through the sterilising pad.

The data and observations made during the course of this series of experiments are tabulated in Table VI.

The pomace extract and citrus pectin series of experiments show quite clearly that the added pectin has been thrown out of solution by some chemical or enzymic agent in the cider. The acidity of the cider (0.35 per cent.) was not high, and the acidity being contributed by a weak acid such as malic acid, it would seem that the active decomposing agent is more probably of enzyme nature. The deposits were all flocculent and white, typical of the precipitates commonly attributed to pectin, and the gradation in the bulk of deposit in the citrus pectin series was most marked. Flavour changes were not well defined, the only effect worthy of mention being the mellowing action of the cold water pomace extract on the flavour of the cider. The dry cider chosen for the basis of this experiment was rather rough, and it is of interest to note that the softening effect of the cold water extract has been greater than that of the sugar, for the sweetened ciders, Nos. 5 and 6, were decidedly rough and unpleasant. But in these experiments again, it is not possible to attribute this difference in flavour solely to the action of soluble pectin, for at the time of tasting the samples the pectin had already been precipitated and little or no soluble pectin material was left in solution. It is probable that the addition of pomace extract contributed to the dry cider other materials besides pectin and it is impossible at the moment to make any definite statement on the precise mechanism of this process.

Substantial agreement is indicated between the result in Table VI with the Seitz-filtered and clarified juices and those obtained for non-alcoholic apple juice in 1932 (4). The calcium pectate content is reduced by passage of the juice through the sterilising filter pad. This effect is much larger in the hot water extract addition where the results were 0.1880 per cent. and 0.2254 per cent. respectively.

TABLE VI.

ADDITION OF PECTIN SOLUTIONS TO DRY CIDERS.

Composition of Test Cider.	Experiment No.	Type of filtration adopted.	Calcium Pectate % in freshly filtered cider.	Appearance after 4 months in bottle.	Flavour after 4 months in bottle.	Calcium Pectate after 4 months in bottle.
Cold Water Pomace Extract.						
4 litres cider	1	Seitz filtered.	0.1403	Brilliant cider, 2in. of heavy deposit.	Definitely softer than 5.	Trace
560 cc.extract. Cane sugar to a gravity of 1.030.	2	Clarified.	0.1443	Brilliant cider, similar deposit.	Softer than 6.	do.
Hot Water Pomace Extract.						
4 litres cider	3	Seitz filtered.	0.1880	Clear, 4in. flocculent deposit.	Extraneous unpleasant flavour, quite unlike 5.	Nil.
600 cc.extract. Cane sugar to a gravity of 1.030.	4	Clarified.	0.2254	Brilliant, heavy deposit.	Rougher than 6.	do.
Control.						
4 litres cider	5	Seitz filtered	0.0162	Darker than No. 6. Slight layer of fine deposit.	Rough flavour with pronounced acetic taint.	Trace.
Cane sugar to a gravity of 1.030.	6	Clarified.	0.0234	Very slight haze : ½in. white flocculent deposit.	do.	do.
Citrus Pectin.						
2 litres sweetened cider 30 cc. 2% pectin solution	7	Clarified.	0.03*	Brilliant cider, slight flocculent deposit.	No significant differences were detected in this series of samples.	do.
2 litres sweetened cider 80 cc. 2% pectin solution	8	do.	0.08*	Faint haze, heavy white deposit.		0.0233
2 litres sweetened cider 140 cc. 2% pectin solution	9	do.	0.14*	Hazy. Very considerable deposit.		0.0254
Control .. .. 2 litres sweetened cider	10	do.	——	Brilliant cider. No deposit.		Nil.

* Indicates approximate citrus pectin percentage added.

SUMMARY.

1. Apple juices macerated with once-pressed pomace dissolve considerable quantities of soluble pectin. The favourable flavour changes in ciders made by this process cannot be correlated directly with pectin data, as the fermented products contained no soluble pectin, this having been removed during fermentation.

2. Ciders fermenting in cask lost most of their pectin (as given by calcium pectate) before fermentation ceased. In a few cases of filtered juices which had been 6 months in bottle, the calcium pectate figure was extremely small, but most of the ciders gave no precipitate at all.

The alcohol precipitate method has been shown to give results very much higher than those for calcium pectate.

3. Samples of sterile pasteurised apple juices fermented separately with 10 different pure yeasts showed no loss of pectin over a 50-day period. In a similar series, not subjected to pasteurisation, approximately 60 per cent. of the pectin was removed. The amount of decomposition varied with the yeast used. The significance of these two observations is indicated and a suggestion is made to account for the observed facts. Complete removal of pectin in one case was correlated with the occurrence of mould growth in the flask.

4. A dry cider to which pectin was added in the form of cold and hot water pomace extracts and as citrus pectin was found to contain no pectin after a few weeks in bottle. Certain flavour changes were noted and these are discussed.

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INVESTIGATIONS ON FRUIT PRODUCTS.

IV.—EXPERIMENTS ON THE CLARIFICATION OF UNFERMENTED AND FERMENTED APPLE JUICE.

By VERNON L. S. CHARLEY.

The second contribution to this series, " Enzymic Clarification of Fruit Juices " (1), contained an historical survey of the various enzymic processes involved, together with a presentation of experimental data contained at Long Ashton by the use of one enzyme preparation on a number of fresh fruit juices. Using only small quantities of material, it was indicated that Pectinol yielded excellent results with strawberry juice, but with juices of higher acidities, such as loganberry, raspberry and blackcurrant, less satisfactory results were obtained. The percentage of enzyme base was varied in each experiment, but the best results were generally given by additions of 1 per cent. of Pectinol. The use of such an enzyme in conjunction with a germproof filter was shown to be followed in some cases by the deposition of a non-yeast material in such quantities as to prejudice the attractiveness of the final product.

Since the completion of the above experiments, other enzyme preparations have been evolved, two of which have been studied at Long Ashton and have given results which it has been considered advisable to publish at this stage.

The experiments described fall naturally into two classes, and are discussed separately as follows :—

A. Clarification of apple juice for non-alcoholic juice production.

B. Clarification of apple juice for cider production.

Apart from the enzyme preparations used, the gelatin + tannin method of classification was included in the tests to compare the effects given by a physico-chemical method with one relying for its efficacy on bio-chemical action.

EXPERIMENTAL.

A. Clarification of Apple Juice for Non-Alcoholic Juice Production.

The clearing materials used in these experiments were :—

Pectinol—pectin decomposing enzyme (on a bran base).
Filtragol— ,, ,, ,, (on a similar base).
Maltolysin—protein decomposing enzyme (on a malt base).
Gelatin + tannin.

Two series of trials were carried out on casks of apple juice, the first bulk of juice being made from mixed cull apples and the second entirely from the variety Annie Elizabeth.

(1) Mixed Cull Fruit.

A quantity of mixed windfall and cull apples, chiefly of Lane's Prince Albert, Bramley's Seedling and King Edward VII varieties, were milled on 2nd October, 1933. The juice was mixed and pumped into five casks, each of thirty gallons capacity, and the juices immediately treated with the various clearing materials. Glass gallon jars were similarly used so that the visible changes in the juices could be more easily followed. The enzymes, etc., were added at 4.30 p.m., and five hours later very little change could be observed, except in the case of the juice treated with gelatin + tannin, which had formed a heavy brown deposit.

Seventeen hours after the commencement of the experiment, two treated juices were outstanding in appearance. The gelatin + tannin addition had resulted in the formation of a compact deposit, leaving the supernatant liquor slightly lighter in colour than the Control, but quite clear. The Maltolysin was by far the most effective of the remaining treatments. The colour of the clear juice was not impaired, and on passing through two thicknesses of muslin the juice was sufficiently clear to bottle without filtration.

Twenty-four hours after the experiment commenced, the various juices were pumped through a small pulp filter previous to germ-proof filtration. The rate of pulp filtration at once afforded unmistakable evidence of enzyme action on colloidal materials. The Maltolysin sample was passed through the filter with the utmost ease, and the other treated juices were only slightly more difficult to manage. The Control sample, however, was still so thick that only a few gallons of clear juice were obtained before the filter became clogged.

The juices issuing from the Seitz filter were collected in glass gallon jars previously sterilised with 2 per cent. SO_2, and these vessels subsequently closed with corks and sealed with paraffin wax. Observations on these samples, and on a further series taken in champagne pint bottles, were made in September, 1934, and again in March, 1935, 17 months after the juices had been bottled.

The data and observations are presented in Table I.

TABLE I.

CLARIFICATION OF MIXED CULL APPLE JUICE.

Treatment of Juice.	Pectinol.	Filtragol.	Maltolysin.	Gelatin + Tannin.	Control (no addition).
Amount added	0.5% (5lb./100 gall.)	0.3% (3lb./100 gall.)	.01%(40 gm./100 gall.)	100 gm. gelatin + 50 gm. tannin/100 gall.	—
Appearance after 17 hours	Very little change.	Slight gelatinous deposit.	Heavy bottom deposit. Clear supernatant juice.	Heavy deposit.	Very cloudy.
Specific gravity of filtered juice	1.047	1.040	1.047	1.046	1.050
Specific gravity after 17 months in bottle ..	1.047	1.039	1.047	1.046	1.050
Clarity after 17 months in bottle	Brilliant.	Brilliant.	Slight haze.	Brilliant.	Brilliant.
Deposit after 17 months in bottle	No deposit.	No deposit.	Gelatinous deposit.	No deposit.	Very slight deposit.
Colour after 17 months in bottle	Slightly paler than Control.	Slightly paler than Control.	Much deeper than Control.	Slightly paler than Control.	Pale.
Flavour after 17 months in bottle	Slightly less character than Control. No extraneous flavour.	Same as Pectinol. Very slight "earthy" flavour.	Definite " pasteurised " taste.	Same as Control.	Deficient in apple character.

(2) Annie Elizabeth Juice.

Fifty gallons of fresh juice were diluted with five gallons of water. The analysis of the diluted juice was: specific gravity 1.048, acidity (as malic acid) 0.74 per cent., tannin 0.12 per cent. The juice was filled into small casks and glass gallon jars, and observations made subsequent to the addition of the various materials. After 48 hours the casks of juice were pulp filtered, and samples taken direct from the filter were pasteurised in bottle. Further quantities of juice were Seitz filtered. The data are given in Table II.

The results of these experiments differed from the first series by reason of the negative results of the Maltolysin. Further, the complicating factor introduced by the early commencement of spontaneous fermentation probably affected the deposition and bulk of some precipitates. Tests on the ease of filtration of the treated juices after 48 hours afforded definite evidence that the addition of the pectin decomposing enzymes, as well as the gelatin + tannin treatment, had removed some viscous materials which made the filtration of these juices much less difficult than the Control and Maltolysin samples.

The small scale laboratory tests, together with the bulk filtration later in the process, indicated that filtration of the fresh juice was considerably quickened by the use of pectin decomposing enzymes. Even in cases where the enzymes gave no visible effects, and where the actual clarity of the juice at the time of filtration was not affected, the benefit was still found in the filtration process. The effect of the various treatments on the clarity and condition of the Seitz filtered and pasteurised juices after a period of 15 months in bottle was not so important, and it is probable that these enzymes will be useful chiefly for reducing the cost of filtration, and not so much for enhancing the appearance of the end product.

Gelatin + tannin proved to be satisfactory, but the ratio of the quantities of the two reagents involved appeared to be important to get the best results. In the two juices under consideration, the gelatin was used in double the amount of the tannin, this ratio having been determined by preliminary experiments to decide on the most satisfactory balance between the two substances.

In the case of the Maltolysin pasteurised sample, in the second experiment, a distinct taste of malt (that being the base on which the enzyme was fixed) was noted, and the other treatments generally caused a reduction in intensity of fruit character. The differences were slight, and it is probable that when a fuller bodied juice is

TABLE II.

CLARIFICATION OF ANNIE ELIZABETH JUICE.

Treatment of Juice.	Pectinol.	Filtragol.	Maltolysin.	Filtragol + Maltolysin.	Gelatin + Tannin.	Control (no addition).
Amount added	0.5% (5lb./100 gall.)	0.3% (3lb./100 gall.)	0.01% (40gm./100 gall)	Filtragol 0.3% Maltolysin 0.01%	Gelatin 80gm. + Tannin 40gm./100 gall.	—
Appearance after 24 hours ..	Cloudy.	Fairly clear.	Cloudy.	Similar to Filtragol.	Quite clear.	Cloudy.
Appearance after 48 hours ..	do.	do.	do.	do.	do.	do.
Deposit after 48 hours ..	Fair quantity.	Considerable gelatinous deposit.	Slight.	As Filtragol.	Very heavy.	Slight.
Clarity of paper filtered juices	Fair.	Fair.	Poor. Same as Control.	Good.	Very good.	Very cloudy.
Appearance of Seitz filtered juices after 15 months.	Clear. Slight deposit.	Very clear. Trace of flocculent deposit.	Cloudy. Slight deposit.	Brilliant. No deposit.	Clear. Very slight haze.	Hazy. Slight trace of yeast deposit.
Colour of Seitz filtered juices after 15 months.	Paler than Control.	Paler than Control.	As Control.	As Control.	Paler than Control.	Pale yellow.
Flavour of Seitz filtered juices after 15 months.	Lacking in character.	Lacking in character.	Very thin.	As Control.	Weak. Very little character	Slight but fresh apple flavour.
Appearance of pasteurised juices after 15 months.	Clear. No deposit.	As Pectinol.	Definite flocculent deposit.	As Pectinol.	Cloudy*	Clear. Slight deposit.
Colour of pasteurised juices after 15 months.	Attractive golden colour.	As Pectinol.	Deep yellow.	Deep yellow.	—	Much deeper than Seitz filtered sample.
Flavour of pasteurised juices after 15 months.	Definite pasteurised taste.	As Pectinol.	Faint taste of malt.	As Pectinol. No malt taste.	Yeast flavour.	Pasteurised flavour.

* Very considerable fermentation had occurred in the case of the Gelatin + Tannin pasteurised sample.

used the effects noted in these experiments will not acquire even the slight significance noted. Maltolysin was unique in affording a deep reddish-yellow coloured juice in the pasteurised series of Annie Elizabeth juice. The specific pectin enzymes appeared to yield paler juices than the Control.

The specific gravities of all except one of the Seitz filtered and pasteurised samples after 15 months were between 1.046—1.048. The pasteurised gelatin + tannin sample had fallen in gravity to 1.042.

The actual flavours of the juices were disappointing, but were similar to those of many samples which have been made during other experiments. The Seitz filtered juices were all weak in apple flavour, although such flavour as was present was notable for its fresh fruit character. The pasteurised samples were distinguished from the filtered juices by their fuller and mellower flavour, but the " cooked " taste, so characteristic of pasteurised juices, was always present. It is possible that the juices sterilised by heat may find more favour than the Seitz filtered samples with the class of consumer who is attracted more by intensity of flavour than by freshness of the apple character. The experiments clearly indicate that the production of attractive non-alcoholic apple juices from the typical cull types of fruit used in the above experiments will need careful study to produce a fully flavoured yet easily filterable product.

B. Clarification of Apple Juice for Cider Production.

The enzyme preparations were again used with a series of apple juices which were later allowed to ferment to a certain gravity before being filtered and bottled. For these preliminary laboratory tests, one gallon of juice was used for each treatment. The enzymes and other materials were allowed to act for 24 hours, when the juice was poured off from the deposit, strained through muslin, and allowed to ferment in jars closed with fermentation locks. At a gravity of about 1.020, which was varied with the acidity of the product, half the quantity of each of the ciders was filtered through the pulp and germproof filters and bottled, whilst the rest was bottled straight from the pulp filter. The data are tabulated in Table III.

The chemical data illustrate the potent effect of the Pectinol and Filtragol products in removing soluble pectin from the juice, the latter enzyme in every case effecting a more considerable removal than the former. As might have been expected, the Maltolysin treatment had in general little effect on the pectin content. It is

TABLE III.

EFFECT OF ENZYMES ON CLARIFICATION OF APPLE JUICES PRIOR TO FERMENTATION.

	Calcium Pectate after 24 hours.	Appearance of Juice after 24 hours.	Condition and appearance of Seitz filtered ciders after 14 months.	Condition and appearance of pulp filtered ciders after 14 months.
SHAPWICK SWEET.				
Pectinol	0.0292*	Much clearer. Considerable deposit	Brilliant. No deposit.	Similar to Control.
Filtragol	0.0264*	Clear. Heavy deposit.	Brilliant. No deposit.	do.
Maltolysin	0.0596*	Same as Control.	Clear. Slight flocculent deposit.	Clear. More deposit.
Filtragol + Maltolysin	0.0262*	Same as Filtragol.	Slight haze. Slight floculent deposit.	Slight yeast deposit.
Control (Calcium pectate = 0.0716% Acidity = 0.16%).	0.0692*	No change in clarity. Slight deposit.	Brilliant. Slight floculent deposit.	Clear. Some flocculent deposit.
SWEET COPPIN.				
Pectinol	0.0184	Same as Control.	Brilliant. No deposit.	Slight yeast deposit.
Filtragol	0.0160	No change in clarity. Fair deposit.	Brilliant. Slight flocculent deposit.	Slight flocculent and yeast deposit.
Maltolysin	0.0390	Same as Control.	Heavy flocculent deposit.	Slight yeast deposit.
Filtragol + Maltolysin	0.0176	Same as Filtragol.	Brilliant. No deposit.	do.
Control (Calcium pectate = 0.0468% Acidity = 0.28%).	0.0392	Faint deposit.	Brilliant. No deposit.	Slight flocculent deposit.
BARN DOOR.				
Pectinol	0.0320	Fair deposit.	Brilliant. No deposit.	The bottles in these two series of ciders all showed signs of considerable fermentation.
Filtragol	0.0196	do.	do.	
Maltolysin	0.0400	Fair deposit. Clearer liquid.	do.	
Filtragol + Maltolysin	0.0140	Heavy deposit. Liquid clear.	Very faint deposit.	
Control (Calcium pectate = 0.0456% (Acidity = 0.83%).	0.0424	Slight deposit.	Brilliant. No deposit.	
COWARNE RED.				
Pectinol	0.0664	Less deposit than Filtragol.	Brilliant. No deposit.	
Filtragol	0.0516	Juice much clearer. Heavy deposit.	do.	
Maltolysin	0.0932*	Same as Control.	Clear. Slight deposit.	
Filtragol + Maltolysin	Trace.	Same as Filtragol.	Brilliant. No deposit.	
Control (Calcium pectate = 0.1212% Acidity = 0.71%).	0.1220	Slight deposit.	Clear. Slight deposit.	
BRAMLEY'S SEEDLING.				
Pectinol	0.0652	Clear. Heavy deposit.	Brilliant. No deposit.	Slight deposit.
Filtragol	Trace.	Very clear. Heavy deposit.	Brilliant. Very slight deposit.	Slight deposit.
Maltolysin	0.0788	Clearer than Control. Slight deposit.	do.	Brilliant. No deposit.
Filtragol + Maltolysin	Trace.	Clearer than Filtragol.	Brilliant. Very slight deposit.	Very slight deposit.
Control (Calcium pectate = 0.0789% Acidity = 0.97%).	0.0800	Very slight deposit.	Brilliant. No deposit.	Cloudy. Slight yeast deposit.

* Denotes that these data refer to analyses carried out 48 hours after addition of enzymes.

remarkable that in the case of Sweet Coppin there was a removal of 50 per cent. of the pectin without affecting the clarity of the juice. The deposits in many cases were too slight to be separated but the juices, even in the presence of the deposit, were filtered with ease on a Buchner funnel packed tightly with filter pulp.

The observations on the Seitz filtered ciders which had been in bottle for 14 months revealed no definite relationships. Most of the ciders were brilliant and the bottles contained only traces of deposit. Three of the Control samples suffered from flocculent precipitates. This is correlated with the higher pectin contents of these samples.

The whole of the Pectinol samples in the five different series of juices were excellent in condition and appearance, as were those from the Filtragol treatment. Maltolysin appeared to be less consistent in its action, being associated with a heavy deposit in one case, and in the Shapwick Sweet and Cowarne Red juices, with a slight precipitate which seemed to be of a pectin type.

The utility of the series of pulp filtered samples is unfortunately vitiated by the incidence of considerable fermentation in the case of all the Barn Door and Cowarne Red samples.

From a study of the above data, it is clear that the enzymes have not had any considerable effect on the appearance or keeping quality of the filtered cider. Their use, as in the production of alcohol-free products to which allusion has already been made, would appear to depend more on their ability to ease filtration and thus to lower the processing costs.

SUMMARY.

(1) Experiments are described on the clarification of cull apple juices by enzymic action, and gelatin + tannin treatment.

Pectin-decomposing enzymes had considerable effects on the ease of filtration of the juice. These were shewn to be more important than differences in clarity in the stored juices or ciders caused by the enzymes. A proteolytic enzyme gave remarkably good results with mixed cull apple juice, but with juice of the variety Annie Elizabeth no such effects were obtained. No outstanding differences due to the treatments were observed in the samples which had been bottled for 15 months.

(2) The clarification of apple juice, later fermented into cider, was studied by using four enzymic treatments on five different

apple juices. Considerable removal of pectin occurred, but this was not always followed by any appreciable clarification of the juice. Filtration after 24 hours was, however, carried out with much greater speed and economy when compared with juices which had not been treated with such enzymes. No significant differences were observed in the filtered samples.

ACKNOWLEDGMENT.

The author wishes to acknowledge the help afforded by Mr. Norman C. Colquhoun, B.Sc., with the experimental work entailed in these investigations.

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PRESERVATION OF FRUIT WITH SULPHUR DIOXIDE.

EFFECT OF HOT AND COLD METHODS ON RESIDUAL SO_2 CONTENT IN JAM.

By VERNON L. S. CHARLEY.

The bulk preservation of fruit for the manufacture of jam is to-day solely effected by some form of sulphur dioxide treatment. The methods of using SO_2 received careful analysis by Barker and Grove (1) and, arising out of their experiments, the cold process treatment was evolved for fruits whose nature was such that the hot process severely deteriorated the fruit. The experiments mentioned provided data on which it was possible to base definite instructions for pulping fruit, and the cold process method has now become an accepted practice in pulping procedure. Very little other work of a scientific nature has been published, but details have gradually been elucidated in works practice concerning the cold and hot processes which have thrown some light on the intricacies of the methods.

Barker and Grove (1) recommended that for preservation in glass containers, capable of being hermetically sealed, the preserving solution should be between 800 and 1,000 p.p.m. of SO_2 in strength, but works experience has shown that the strains and stresses to which the casks containing the pulp are subjected results in a considerable loss of SO_2 by evaporation; at the same time, air is likely to gain access to the pulp, and the atmospheric oxygen will further reduce the free SO_2 by its oxidation to sulphuric acid. Consequently the practice has been to increase the amount of SO_2 to 1,500 p.p.m., although even in this case it is necessary to examine the pulp periodically to determine whether sufficient preservative remains.

The form in which the SO_2 is added to the fruit might not at first sight be suspected of having any significance, but this is not the case. The chief sources of SO_2 that are commonly used to-day are liquid SO_2, 6 per cent. SO_2 aqueous solution, potassium metabisulphite and calcium bisulphite (7 per cent. solution). No data are available which show the respective effects of the potassium salt and sulphurous acid, but it is now generally accepted that the effect of the calcium bisulphite is to harden the tissues of the fruit. This is an advantage in the case of certain fruits like the strawberry and raspberry, but is definitely a defect in the case of cherries and plums (2).

A difficulty has been encountered by the jam manufacturers, arising from the Ministry of Health's regulation introduced in 1927, which imposes a maximum figure of 40 parts per million of SO_2 in a finished jam offered for sale. It has been found that when fresh fruit has been pulped (generally by the hot process), and the necessary amount of preservative added, there is some difficulty in removing sufficient SO_2 in the boiling process to satisfy the above legal requirements. Especially is this so in the case of black-currants, and it has been known to be necessary to add a further quantity of water to the batch and continue the boiling in order to remove a sufficiently large proportion of SO_2. This protracted boiling obviously reflects adversely on the fresh fruit flavour of the jam.

It was as a result of problems such as the above, that a programme of work was commenced at Long Ashton in 1932 to study certain aspects of fruit pulping.

In the first place, it was intended to investigate the effect of the various means of preservation on the residual SO_2 content of the jam. Whilst this work was in progress on fresh plums, the most appropriate fruit available when the experiments were initiated, the question of the distribution of SO_2 in the different tissues of the fruit was raised, and a series of experiments were devised to determine whether any of the results observed in practice could be explained by a consideration of this further point. In view of the tendency of SO_2 to combine with a variety of organic compounds, it was thought possible that the different tissues of the plums, such as skins, flesh and stones, on account of their varying compositions and textures, might retain the SO_2 in varying proportions. It has been stated in jam-making circles that in plum jam most of the preservative resides in the stones, and a short series of experiments was carried out to test the truth of this assertion and to determine whether any differences that may exist are related to the strength of the preserving solution. The results of the two series of experiments are reported in this article. The report on the succeeding investigations concerning problems associated with other fruits will appear later.

EXPERIMENTAL.

I. Experiments comparing the Cold and Hot Processes of Preserving Plums.

13 cwt. of Coe's Late Red Plums were used for the experiments. The fruit was slightly under-ripe and in very sound condition. The various treatments of the fruit were carried out on September 20th, 1932, according to the following scheme.

A. Cold Process.

Six 15-gallon casks were tightly packed with plums and covered with the undermentioned solutions :—

A.1. 1,000 p.p.m. sulphur dioxide (water solution).
A.2. ,, ,, ,,
A.3. ,, ,, (Potassium metabisulphite).
A.4. 2,000 p.p.m. sulphur dioxide (water solution).
A.5. ,, ,, ,,
A.6. ,, ,, (calcium bisulphite).

Approximately 97 lbs. of plums and 4 gallons of preserving solution were used for each cask. The solutions were carefully tested and brought to the exact strength required immediately before being poured into the vessels.

B. Hot Process.

7 cwts. of plums were pulped in a 150-gallon wooden vat provided with a false bottom, perforated with a number of circular holes. Beneath this was a four-way steam distributor. Steaming was continued until the plums were thoroughly softened when the pulp was received in a further series of 15-gallon casks, and the following amounts of preservative thoroughly incorporated by agitation and rolling.

B.1. 3,000 p.p.m. SO_2 (as potassium metabisulphite).
B.2. 1,500 p.p.m. SO_2 ,, ,,
B.3. 500 p.p.m. SO_2 ,, ,,
B.4. 3,000 p.p.m. SO_2 (as calcium bisulphite).
B.5. 1,500 p.p.m. SO_2 ,, ,,
B.6. 750 p.p.m. SO_2 ,, ,,

The potassium salt was added in solid form, and the calcium bisulphite as the commercial 7 per cent. solution.

The casks were tightly bunged down and stored in a cool place for one month.

Conversion of Pulp to Jam.

In present day commercial procedure, the quick-boil process, associated with the addition of pectin, is almost universally adopted. About 120 lbs. of jam are made at each boil, but in consequence of practical considerations concerning the size of the available jam pan, it was decided to make only 80 lbs. of jam at each batch in these experiments. A steam jacketed copper jam pan of orthodox shape and heating surface was used. The jam was made according to the following formula :—

Fresh fruit, 27 lbs. ; Water, 12½ lbs. ; Sugar, 50 lbs. ; Pectin, 4 ozs. ; Tartaric acid, 1¼ ozs.

It was found that in the cold process casks, the 4 gallons of liquid originally added had increased to 5 gallons, this being caused by diffusion of juice from the fruit. Thus, the total weight of juice in each cask was practically the correct weight of liquid to use with the corresponding quantity of fruit. 27 lbs. of plums were weighed out and mixed with 12½ lbs. of juice in the jam-pan. Steady heat was applied and at 190°F. the pectin was sifted in with continuous stirring. After hard boiling for 1 minute the sugar was added, and the contents of the pan boiled until the temperature reached 221°F. The time taken for this was about 8 minutes. The tartaric acid was added, and the jam allowed to cool somewhat before being bottled into various sized vessels (1 lb., 2 lb. and 7 lb. jars).

In order to obtain a duplication and check on the loss of sulphur dioxide during the boiling process, two complete boils of jam were carried out on each cask of material used for the experiments.

Analysis.

The determination of SO_2 was effected by means of the Monier-Williams distillation method (3). Duplicate analyses were carried out on each sample.

Results.

The chemical data obtained are presented in Table I.

The salient feature of the results of the cold processing experiments is the wide differences in residual sulphur dioxide in jams made from fruits preserved with 1,000 and 2,000 p.p.m. of preservative. It will be seen that the lesser quantity of preservative allowed a jam to be made containing only half the legal maximum

TABLE I.

Effect of Preservation Treatment on Residual SO_2 in Jam.

Sample.	Batch.	Process.	Form of Preserving.	SO_2 in Preserving Solution (cold process) or Pulp (hot process). p.p.m.	SO_2 in Jam in p.p.m. (Averages).
A.1	a	Cold	SO_2 solution	1000	18
	b	,,	do.	,,	21
A.3	a	,,	SO_2 solution (as potassium metabisulphite)	,,	19.5
	b	,,	do.	,,	19.5
A.4	a	,,	SO_2 solution	2000	70.5
	b	,,	do.	,,	71
A.6	a	,,	SO_2 solution (as calcium bisulphite)	,,	53.5
	b	,,	do.	,,	56.5
B.1	a	Hot	Potassium metabisulphite	3000	113.5
	b	,,	do.	,,	126.5
B.2	a	,,	do.	1500	89.5
	b	,,	do.	,,	87
B.3	a	,,	do.	750	84
	b	,,	do.	,,	84.5
B.4	a	,,	Calcium bisulphite	3000	154
	b	,,	do.	,,	159
B.5	a	,,	do.	1500	127
	b	,,	do.	,,	126
B.6	a	,,	do.	750	86.5
	b	,,	do.	,,	85

amount of sulphur dioxide, whereas with the stronger solution this maximum was considerably exceeded. The effect of substituting potassium metabisulphite for the sulphurous acid solution (1,000 p.p.m.) was negligible, but a significant difference was found in the stronger solutions when the simple preservative was replaced by calcium bisulphite. No explanation is available to account for this result.

The hot processing had evidently resulted in a more complete incorporation of preservative in the fruit tissues, resulting in the "fixation" of a proportion of the SO_2 with aldehydic and similarly constituted organic compounds ; it is known that such compounds are only held together by loose linkages but apparently they are stable under the conditions of temperature, pH, etc., existing in the jam boiling process. The preservation of hot pulp with 750 p.p.m. of sulphur dioxide was followed by the preparation of a jam which contained over double the legal amount of SO_2 (86 p.p.m.), whilst by using higher strengths of preservative the residual SO_2 was very considerably increased. Well-defined differences were observed between the residual SO_2 figures in comparable jams made from pulps preserved with the potassium and calcium materials; the calcium bisulphite gave higher results at all three strengths, but whereas the difference is negligible at the lowest concentration (750 p.p.m.), the higher amounts of preservative afforded entirely significant results. The experiments show clearly the advantage possessed by the cold process when compared with the hot pulping method, but no definite evidence is afforded on the matter of suitability of the various means of introducing SO_2 into the fruit.

Effects of Treatments on Jam Quality.

The various samples of jam were inspected for the following points: flavour, consistency, colour, condition of skins and fleshy tissue of the fruits.

Several points arising from the data presented in Table II call for specific mention. The "woody" flavour detected in all the hot processed pulp jams was ascribed to the fact that the casks in which the hot pulp was placed previous to storage had not been suitably treated to remove the characteristic compounds that are associated with new wood. The casks were purchased as "re-mades," in which case it was expected that the wood had been previously "exhausted," but this was not the case. It is a matter of interest in this connection, however, to note that no similar flavour was detected in the cold process pulp jams.

The effect of the various treatments on the consistency of the jam is not consistent, as shewn by the experimental results. In the cold process series, the increase of SO_2 from 1,000 to 2,000 p.p.m. has been followed by a poorer "set," and in the case where calcium bisulphite was used the effect of the preservative was most marked in this direction. The coincidence of the weak jelly strength with the use of the calcium compound is perhaps significant in view of the recent suggestion by Potter (4) that calcium bisulphite should not be used with certain fruits on account of its tendency to precipitate the pectin after prolonged storage and hence to weaken the "set." The condition of the jams made from the hot-pulped fruit did not show any definite correlation with SO_2 content.

In the question of colour, the jams made from the whole fruit pulps were attractive and light, but the hot processed material was converted into jams which were much darker, and which had lost the typical plum green colour associated with the other series.

TABLE II.

Effect of Preservation Treatment on Flavour and Quality of Jam.

Sample.	Process.	Method of Preservation.	Flavour.	Consistency.	Colour	Condition of Fruit.
A.1	Cold	1000 p.p.m SO_2 solution	Rather sweet	Good	Good	Fruit whole and tender.
	,,	do.	No taste of SO_2			
A.3	,,	1000 p.p.m. (as potassium metabisulphite)	Rather sweet	,,	,,	Flesh inclined to cling to stone.
	,,	do.	No taste of SO_2			
A.4	,,	2000 p.p.m. SO_2 solution	Sharper than A.3	Tendency to weep	,,	Skins tough and wrinkled.
	,,	do.	Trace of SO_2 detectable	Not so good as A.1 & 3		
A.6	,,	2000 p.p.m. (as calcium bisulphite)	Similar to A.4	Very poor set	,,	Skins and flesh tough : flesh clinging to stones.
	,,	do.	Slight trace of SO_2			
B.1	Hot	3000 p.p.m. (as potassium metabisulphite)	Very "woody" flavour	Very good set	Dark	Completely disintegrated. Skin portions very tough.
	,,	do.	Definite taste of SO_2			
B.2	,,	1500 p.p.m. (as potassium metabisulphite)	" Woody " flavour	*Not so good as B.1	,,	do.
	,,	do.	Slight taste of SO_2			
B.3	,,	750 p.p.m. (as potassium metabisulphite)	" Woody " flavour.	Good	,,	Completely disintegrated. Skins soft.
	,,	do.	Trace of SO_2			
B.4	,,	3000 p.p.m. (as calcium bisulphite)	" Woody " flavour	Fair	,,	Completely disintegrated. Skins rather tough.
	,,	do.	Strong taste of SO_2			
B.5	,,	1500 p.p.m. (as calcium bisulphite)	" Woody " flavour. Distinctly more acid than B.4	,,	,,	do.
	,,	do.	Definite taste of SO_2			

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* Some pectin was not dissolved in this boil, which accounts for the somewhat poorer set of the sample.

Considerable differences were noticed in the condition of the fruit itself in the final jam. In jams made from cold processed pulp containing 1,000 p.p.m. of SO_2, the fruits were nearly all in a whole condition and were quite tender, but the stronger preservative had resulted in a toughening of the skins, which was a distinct disadvantage. Many of the fruits had shrivelled and formed compact centres of hardened tissues. In the hot treatment, the plums were completely disintegrated under the conditions of the experiments, but the effects of the larger proportions of preservatives were noticeable in the hardening of the pieces of skin distributed throughout the jam.

II. The Distribution of Sulphur Dioxide in the Various Tissues of Preserved Plums.

Owing to the almost complete disintegration of fruit in the hot processed series, only cold preserved plums were examined, namely those treated with sulphurous acid containing 1,000 and 2,000 p.p.m. of SO_2. The procedure adopted was as follows :—

The plums were taken from the cask and carefully wiped to remove the bulk of the adhering liquor. Six fruits were quickly skinned with a sharp scalpel, the skins being scraped free from flesh and placed in a small, tightly closed weighing bottle. The flesh was dissected, and the stones cleaned by vigorous scraping, and broken in half. The skins, flesh and stones were immediately weighed separately and transferred to three Monier-Williams distillation flasks, and the estimations carried out. The liquid from the cask was also analysed. The results are given in Table III.

TABLE III.

DISTRIBUTION OF SO_2 IN STONES, SKINS, FLESH AND LIQUOR IN PRESERVED PLUMS.

Tissues.	Preserving Solution.			
	*1000 p.p.m. SO_2	1000 p.p.m. SO_2	*2000 p.p.m. SO_2	2000 p.p.m. SO_2
Stones	320	520	700	985
Skins	144	110	280	414
Flesh	163	137	166	314
Liquor	180	178	210	538

* Indicates that samples were taken from a quarter empty cask.

The data clearly show that the stones contain considerably more SO_2 than either the flesh or the skins of the preserved plums. The differences between the SO_2 contents of the skins and flesh are in agreement in different experiments on similarly treated fruit, but whereas the skins contained more SO_2 than the flesh in the fruits treated with the weaker preservative, this was reversed when the 2,000 p.p.m. solution was used. The data are presented here without further comment, as work on the question of distribution is being continued.

SUMMARY.

1. The effect of various pulping treatments of plums on the residual SO_2 content of the jam prepared from the pulps has been studied.

Plums processed in the cold with 1,000 and 2,000 p.p.m. of SO_2 gave jams which contained 20 and 70 p.p.m. of SO_2 respectively.

With this process the use of calcium bisulphite resulted in a lower residual figure, but the data with potassium metabisulphite indicated no significant deviation from the ordinary sulphurous acid method.

A considerable increase in residual SO_2 (84-126 p.p.m.) was observed in jams made from hot processed pulps.

2. The skins of the whole fruit preserved in the cold by the stronger solution became toughened, and this condition persisted in the jam.

3. The hot processed pulp yielded darker jams in which the fruit was completely disintegrated. Much higher amounts of residual SO_2 remained in the jams.

4. The stones of cold processed plums were found to contain much more SO_2 than the skins and flesh.

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THE BASKET WILLOW CROP.*

By H. P. HUTCHINSON.

It is usual in a discourse on the cultivation of Basket Willows to confine the remarks almost exclusively to a description of those practical methods of husbandry which are associated with crop management. The subject matter of this paper, however, refers mostly to the results of the advisory and experimental work which has been in progress at Long Ashton for the past ten years, the object being to emphasise the points of particular scientific interest. Although the subject is wide in its range, the general principles involved in the cultivation of the crop should be clear from the outline given.

Suitability of Site.

The extensive leaf area, the thinness of the laminae, the presence of stomata on both sides of the leaf, the extensive and highly absorptive root system, the great capacity for internal transit of water due to the large number and size of the tracheids and vessels of the wood, the response made to water as a growth factor and the natural habitat of the plant all indicate that those areas which verge on the water limits of cultivation are likely to be the most satisfactory sites for the establishing of the crop.

Land of this type is plentiful. Thousands of acres of it exist in river valleys, and in coastal and estuarine regions. As such land in most cases is economically unproductive and unsuitable for other crops, the willow occupies a unique position, since although it will succeed on relatively high lying land, it need not encroach on land which can be put to other agricultural uses.

The chief factor affecting growth is the water supply. Willows thrive when large quantities of water are present in the root regions. Cases are known where good growth is made when the water table for the greater part of the year is not lower than 18 inches and frequently rises to the surface as flood. Sewage farms are examples of such conditions.

It is, however, of the greatest importance to note that under these conditions the water is in a state of movement, "coming and going," *i.e.* the natural drainage for the crop is good. Stagnancy always seriously checks growth and when acting with other adverse factors may cause death.

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* Substance of a paper read before the Botanical Section of the British Association, Aberdeen, 1934.

The dense root masses of willows frequently formed in the waters of running streams suggest that the beneficial action of large amounts of moving water may be due to the satisfactory aeration provided. This view is supported by the fact in the culture work carried out at Long Ashton, willows grown in tap water made much better growth than those grown in water which had been previously boiled.

An essential condition in considering the suitability of any land for the willow crop, therefore, is satisfactory drainage. This control of the water supply can generally be achieved by keeping the channels of all the watercourses in the immediate district clear of obstructions and by the construction of open drains across the land. If ploughing, and afterwards planting, be carried out in the direction of natural surface slope, the open furrows can be made to act as surface drains by connecting their ends with bordering ditches.

In Somerset, where the willow land is, on the average, 16 feet above sea level and the sea 18 miles distant, drainage of the area is effected by the use of pumping stations situated on the banks of the Parret. The water is pumped into the river at neap tide.

Varietal Characters.

Varieties of basket willows differ greatly amongst themselves in pliability, lateral branching, relation of length to thickness, colour as white and buff, susceptibility to insect and fungus injury, productivity, suitability for the different kinds of wicker articles, and in suitability for any particular type of land.

Certain of these characters are discussed below :—

Pliability. Basket makers always require a rod of suitable size which can be twisted or bent with ease and with a minimum amount of fracture. Differences in pliability are easily demonstrated but the subject has not received sufficient investigation by the research worker to admit of explanation. A large amount of pith relative to wood often serves as an indication of inferior quality but not always. The converse is also inconsistent. Differences in texture of the wood, as shown by the number and size of the vessels, are not reliable. Constant differences in shape and size of the wood fibres have not been detected, but the opinion is held that pliability may be associated with difference in the composition of the cell walls.

Lateral branching is a varietal character. *Purpurea* and *viminalis* varieties show little of it, but many varieties of *triandra*, and the tree willows also, branch so profusely as to render their rods worthless. Side branching occurs as a result of injury to growing points and young heads are more subject to it than older heads. Admission of too much light, which occurs in the first year or two of newly-planted beds, too wide planting distances and neglect in refilling gaps in an established bed also result in the production of branched or " rough " rods.

It was observed in the course of the pot culture work at Long Ashton that no lateral branching occurred in the cases where potassium was omitted from the nutrient solution.

Length and Thickness. This relationship is important and again a varietal character. Rods should be, throughout their lengths, as uniform as possible in diameter, *i.e.* the taper should be as gradual as possible. Thick butted rods make indifferent basketry.

Colour. Peeled rods are either white or buff. White rods are prepared in the spring by removing the bark immediately sap movements are sufficiently active to enable the operation to be performed. In peeling for white the following facts are of interest :

The time during which white can be prepared from freshly cut rods seldom extends beyond 12 days because of the formation of new wood which, when dry, causes discolouration and breaks away as a ragged rind. In practice the peeling period is prolonged by cutting rods in winter and placing them on their butts in water. Growth is thus retarded and the rods may be peeled successfully until the following July. Other methods of preparing for white are described in the Ministry of Agriculture's publication. (1)

A willow rod in the peeling stage presents the following points of physiological interest :—

(1) It will peel freely in the upper parts several days before the bark can be removed at the butt end.

(2) The facility with which the operation can be performed varies with temperature. A cold interval intervening between warm periods during the day and cold days following warm ones will cause retardation of cell activities to such an extent as to render the rods unpeelable.

(3) Good white can be produced in August, *i.e.* when the optimum period of growth is passed, and the new wood adheres firmly to the old. Such rods are known as "Lammas White."

(4) Experimental work has shown that at suitable temperatures the peeling condition can be hastened. On January 15th, 1932, rods of 25 varieties of willows were placed in a greenhouse at a temperature which ranged from 50° to 60°C. Peeling commenced on February 15th with Black Hollanders and finished with Dutch on March 12th, the order of peeling being the same as when grown outside but two months earlier.

(5) Rods of all varieties of *S. purpurea* make unsatisfactory white because of the discolouration which appears on the wood as the result of decomposition of the organic substances present in the cell sap. This effect can be largely prevented if the rod is wiped with a wet cloth immediately after peeling. Rods of *S. triandra* varieties make the finest white.

Buff rods are prepared by peeling rods which have been boiled for several hours.

The points of interest arising in connection with the process are :—

(1) Rods of all varieties of *S. triandra* buff well, giving dark colour.

(2) Rods of all varieties of *S. viminalis* make pale buff.

(3) Rods of all varieties of *S. purpurea* make very pale buff and require 2—3 weeks' exposure to sunlight before the required intensity of colour is obtained. The colour is due to the presence of organic substances in the cells of the cortex, which on liberation colour the wood. Chemical work on the constituents of willow bark has shown these products to be derivatives of catechol and pyrogallol. Experiments at Long Ashton have proved that in the presence of mild alkali, such as lime water and washing soda, decomposition followed by colouration takes place readily. By this method the two or three weeks required by *S. purpurea* varieties can be reduced to a few minutes.

(4) Different kinds of soil have marked effects on the buff colour produced even with the same variety. Black Maul, a *triandra* variety, which when grown on clays and marls gives a good buff, fails to produce the colour when grown on peat.

Insect Pests and Fungus Diseases.

Insect and fungus pests are serious. In every case a considerable amount of scientific research is still required before a stage of complete economic control can be reached. This work involves :—

(1) A detailed study of the life history of the pests.

(2) The testing of insecticidal and fungicidal preparations with a view to ascertaining their values as protective agents and the stages when the pests are most susceptible to treatment.

(3) The devising of methods whereby applications can best be made, which frequently involves matters of machine construction.

(4) The costs of treatments and the devising of methods whereby these costs may be reduced.

As an example of the value of research as an agent of progress, the complete control of the very destructive beetles, *Phyllodecta* and *Galerucella* by the discovery of the toxicity to adults of rotenone, a constituent in derris root, may be cited. Further, as the result of acquiring a detailed knowledge of the life histories of these beetles, together with the discovery of an efficient spreading agent incorporated in lead arsenate sprays, effective control of the insect when in the larval stage has been secured, after years of expensive and ineffective use of this poison.

Progress in the control of fungus diseases is much behind the stage reached in the case of insects, probably because the humid conditions are particularly favourable to fungus growth.

Melampsora and *Physalospora* do great damage at times, due to the fracture which results at those places in the rods where fungus lesions are formed.

Copper applied as Bordeaux mixture has been found by laboratory and small field experiments to check spread, but under general field conditions effective application is hardly possible on account of the difficulty of access to the beds owing to the density of growth of the crop. The most promising line of work towards control is in the direction of early spring spraying, which has arisen as the result of the recent discovery that first infections of young leaves take place by spores which develop from the teleutospores on the dead leaves of the previous crop, no alternate host being concerned.

Planting.

Vegetative propagation is exclusively practised. Two-year-old and one-year-old rods cut into lengths of from 10 to 18 inches are pushed into prepared ground during the winter months at distances depending on variety. These distances fall between 18 and 24 inches between the rows, and 12 and 18 inches between neighbouring plants in the same row. All directions are given in the Ministry of Agriculture's publication on this subject. (1.)

The growth behaviour of cuttings presents the following points of interest :—

(1) Sets taken from one-year-old rods produce plants as readily as sets from two-year-old rods, but sets from three-year-old and older rods frequently fail to grow.

(2) If the season following planting be moist, the upper parts of rods form stronger plants than sets taken from the thicker and lower part of the rod. In dry seasons the reverse is the case.

(3) Growth consists in the formation of shoots from the buds and simultaneously the growth of roots. The latter arise from initial root masses situated on the cambium ring. Under some conditions roots arise from a callus.

Cultivation.

As in the cases of other crops cultivation consists in the carrying out of operations designed to encourage the influence of those ecological factors which favour the growth of the willow, with suppression of those which act adversely.

The best check that can be applied to the growth of plants natural to the soil, but weeds as far as the willow crop is concerned, is to invert the turf or top furrow slice as deeply and thoroughly as circumstances permit prior to planting. The plough assisted by the use of the spade suffices. By this means the willow plants root and develop shoots before the struggle for light between them and the weeds begins. Cultivation in the form of hoeing may be necessary during May and June.

In general, throughout the lifetime of the bed, the greatest enemies to the willows are the weed plant associations, grasses, reeds, rushes, woodbine and briars, which, if unchecked, rapidly kill the willows by excluding light from the growing shoots, especially in spring. The necessary check to their progress is given by hoeing, hand cutting the weeds in summer, and in some cases by grazing with cattle in early spring. A full crop of willows, if allowed to stand uncut for two years, frequently attain, by light suppression, such an ascendency over the lower vegetation as to render cultivations for the following year unnecessary. *Viminalis* and its hybrids, by the height which they attain and the density of their growth, are particularly suppressive in this way.

Under good management, which in essence is mainly weed suppression, and given a suitable soil, a willow bed will, yield satisfactory crops for 20 years or more. A bed known to the writer is in its fifty-first year and continues to grow good crops. A bed generally becomes derelict through neglect. A dead head is not replaced and weeds, grasses, etc., assert a mastery over neighbouring plants, killing, by light suppression, as they extend. The weed patches coalesce and the bed rapidly becomes derelict ; a fox cover, irrecoverable.

The Growing of Willows from Seed.

Under suitable conditions willows can easily be raised from seed.

During the past seven years thousands of seedlings have been raised at Long Ashton, in the early stages from seed produced naturally and more recently from seed produced under controlled breeding.

The objects of this branch of the willow work are :—

(1) To produce varieties resistant to disease.

(2) To produce varieties combining in the individual the desired qualities of the parents, such as large size and good wood qualities.

(3) To produce varieties suitable to the different types of soil.

(4) Generally to produce varieties superior to those now grown.

Some of the results have already been published as articles in the Long Ashton Station Annual Report.

Economics.

The economic aspect cannot be fully considered in this short paper. The main conclusion to be gathered from the figures supplied by the economists is that the industry suffers great losses from want of sufficient scientific help, particularly in the control of pests. Some progress has been made on these lines but much more scientific work is required before the art of cultivation can reach a standard where returns commensurate with the expenses and energy now bestowed upon the crop can be realised.

The nation's requirements in basketry are extensive, there being a constant demand for baskets in the factories, warehouses, offices and shops of many industries as well as for universal general domestic use.

The soil and climate of this country are most favourable and there is an abundance of land now more or less waste on which willows of the finest quality could be profitably grown.

REFERENCE.

(1) "The Cultivation of Osiers and Willows." *Ministry of Agriculture and Fisheries, Miscellaneous Publication, No.* 18.

A SURVEY OF THE SOILS OF THE TEART LAND AREAS OF SOMERSET.

PROGRESS REPORT NO. 1.

By D. A. OSMOND.

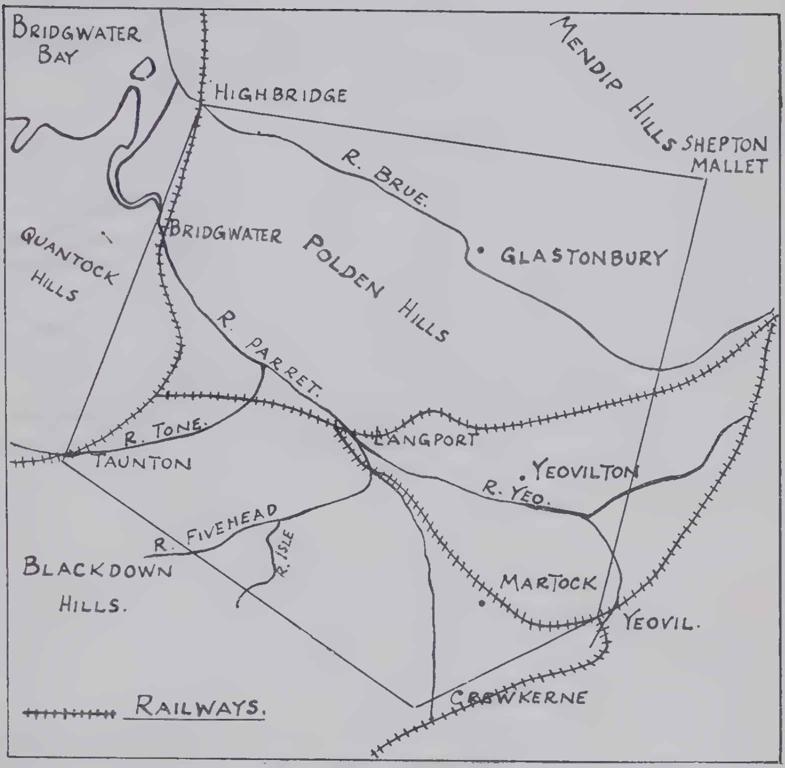
In previous investigations on Teart Lands in Somerset and Warwickshire, Gimingham and others (1, 2, 4) have shown that soils of reputed teartness occur in association with the Lower Lias Formation. Further investigations of the problem by workers in this Department have shown that the soils in both the Somerset and Warwickshire teart areas are very varied, and so far no simple relationship has been established between teartness and a particular class of soil. In view of these findings, it has been felt that before substantial progress can be made with the problem of relationships between teartness and soils, it will be necessary to make a detailed classification of the soils of the teart areas, and this work has accordingly been commenced in Somerset.

The area selected for study is bounded roughly by lines joining the towns of Highbridge in the north-west, Taunton in the west, Crewkerne in the south, Yeovil in the south-east, and Shepton Mallet in the north-east, and comprises approximately 370 square miles.

Besides containing districts of reputed teartness this area also includes the important cider fruit area around Martock, and it is proposed to pay special attention to these fruit soils with a view to determining relationships between fruit and soil conditions.

The soils of the area are being classified and mapped in accordance with the methods described in the report of the Soils Correlation Committee, 1931 (3), mapping being carried out on a scale of 6 inches to 1 mile.

Up to the present time, the work done has been mainly of the nature of a reconnaissance survey in which special attention has been given to the occurrence of geological drift deposits likely to complicate the distribution of the soils, but considerable progress has also been made in recognising soil series and in mapping particular localities.


BRIDGWATER BAY
HIGHBRIDGE
MENDIP HILLS
SHEPTON MALLET
R. BRUE.
QUANTOCK HILLS
BRIDGWATER
POLDEN HILLS
GLASTONBURY
R. PARRET.
R. TONE.
TAUNTON
LANGPORT
YEOVILTON
R. YEO.
R. FIVEHEAD
R. ISLE
BLACKDOWN HILLS.
MARTOCK
YEOVIL.
CREWKERNE
RAILWAYS.

Sketch Map of the Area to be Surveyed.

Physiography of the Area.

From the accompanying sketch map, it can be seen that the area is drained by two river systems separated by the Polden Hills. The larger of these is that of the river Parret and its tributaries, the Tone, Fivehead, Isle and Yeo, all lying to the south of the Polden Hills. The other is that of the river Brue and its tributaries, which drain the region lying between the Mendip Hills and Polden Hills.

The salient feature of the topography of the area is the large proportion of land under 200 feet above sea level, much of which is " moor " land at an elevation of only a few feet above sea level.

Prominent features of the higher land are the Polden Hills running almost due east and west and a crescent-shaped ridge curving to the south-west from the eastern end of the Poldens.

Hilly land is again encountered in the south and south-east around Crewkerne and Yeovil, whilst a small shoulder of the Quantock Hills occurs to the north of Taunton.

Geology.

The oldest geological formation shown on the " solid " geological map of the area is the Devonian Formation, which comprises the Quantock Hills. The Keuper Formation is generally found at the foot of the escarpments bordering the " moor " land, the Rhaetic and Lower Lias Formations capping the Keuper Formation. The Lower Lias Formation covers a moderately large part of the area, and in general has a gentle slope from west to east. The Middle Lias Formation occurs around South Petherton and Yeovil, and two smaller outliers also appear at Glastonbury and at East and West Pennard. The surface deposits of the river valleys and the " moor " land are composed of alluvium, and sand and gravel deposits are shown as occupying some of the slight rises in these regions.

The Keuper Formation is represented by the Keuper Marl, which is a red, stoneless, generally non-calcareous clay. The Rhaetic and Lower Lias Formations are very similar and consist of fine grained limestones of variable thickness alternating with heavy calcareous clays of a blue-grey colour.

Much of the area shown as alluvium consists either of a layer of mineral soil of variable thickness overlying peat, *e.g.* Sedgemoor, Aller Moor and parts of West Moor, or a considerable thickness (5—6 feet) of mineral soil may be present as at Kings Moor and West Moor. In other parts, however, the river deposits take the form of river terraces composed of gravel over which a second deposit of river alluvium has been laid. Near Yeovilton and Podimore these gravels are composed of Liassic and Oolitic fragments derived from the neighbouring hills. On the other hand, the gravels of the river Isle, whilst composed mainly of Liassic material, also contain large quantities of flint and chert from the Chalk beds lying to the south.

The presence of these various solid formations and superficial deposits gives rise to several soil series.

Soils.

Soils have been described on the basis of the soil-profile as seen in the face of small pits, and maps, on a scale of 6 inches to 1 mile, are being prepared showing the boundaries of each series.

During the past season, approximately 24 square miles were mapped in two areas (1) the valley of the river Isle to the south-west of Langport, and (2) a smaller area in the valley of the river Cam. These districts were chosen on account of the comparatively large acreage of reputedly teart land within them and also because they present interesting points in connection with the geology of the superficial deposits.

In these two regions 19 soil series have been mapped, and of these 12 have not been previously described. The following are the characteristic features by which the seven previously known series are recognised :—

(1) *The Evesham Series*—highly calcareous, moderately well-drained brownish-grey clay, passing into a highly calcareous blue-grey clay at depths varying from 2 to 3 feet.

(2) *The Haselor Series*—highly calcareous, moderately well-drained blue-grey or brown clay, with limestone rock at or near the surface.

(3) *The Charlton Bank Series*—slightly calcareous, dark brownish-grey clay, overlying a bright orange or yellow clay, which in turn overlies highly calcareous blue-grey clay. This corresponds to the Evesham series under conditions of strongly impeded drainage.

These three series are developed on the Lower Lias Formation.

(4) *The Worcester Series*—brownish-red, moderately well-drained heavy loam or clay, generally non-calcareous, extending to 4 or 5 feet.

(5) *The Worcester (Shallow Phase) Series*—a similar brownish-red heavy loam or clay overlying red unweathered marl at about 18 inches.

These two series are developed on the Keuper Marl Formation.

(6) *The Wyre* (?) *Series*—dark brown clay overlying grey-brown clay, generally non-calcareous and moderately well-drained.

(7) *The Fladbury* (?) *Series*—similar to the Wyre series, but with much rusty-coloured mottling in the surface layers particularly around grass roots, etc. The water table in this series is at or very near the surface.

These two series are developed on alluvium, but it is not yet certain that they are the same as the Wyre and Fladbury series.

Of the twelve new series, eight cover considerable areas, whilst four are only of local development. Some of the characteristic features of them are described below.

The river terraces of Yeovilton and Podimore give rise to at least three soil series, one of which has been tentatively named the Speckington Series.

(8) *The Speckington Series*—8″—13″ of a greyish-brown medium loam to fine sandy loam overlying highly-calcareous Liassic gravel of variable thickness resting directly on blue-grey highly-calcareous Lower Lias Clay.

(9) *Unnamed*—greyish-brown medium loam to fine sandy loam 3—4 feet thick, resting directly on the Lower Lias Clay.

(10) *Unnamed*—greyish-brown medium loam to fine sandy loam 18 inches thick, resting directly on Lower Lias Clay.

The soils of these three series appear to have good drainage.

Nos. 9 and 10 are only differentiated by the depth at which the Lower Lias Clay appears and may be regarded subsequently as shallow and deep phases of the same series.

In the valley of the river Isle, the river terraces give rise to at least two new series, one of which has been named the Hambridge Series.

(11) *The Hambridge Series*—7″ of grey-brown fine sandy clay with rusty-coloured mottling, overlying 7″ of light greyish-brown fine sandy clay, containing a high proportion of flinty gravel, with much rusty and yellow-coloured mottling and concretions of iron oxides. Below, the blue-grey Lower Lias Clay appears. The soils of this series have somewhat impeded drainage.

(12) *Unnamed*—grey-brown fine sandy clay with practically no mottling, overlying grey-brown fine sandy clay containing much flinty gravel, resting directly on the

Lower Lias Clay. This series appears to be developed on the same deposit as the Hambridge Series, but under conditions of better drainage.

REFERENCES.

(1) Gimingham, C. T. The Scouring Lands of Somerset. *J. Board of Agric.* Vol. XVII, p. 529. 1910.

(2) Gimingham, C. T. The Scouring Lands of Somerset and Warwickshire. *J. Agric. Sci.* Vol. VI, p. 328. 1914.

(3) Soils Correlation Committee. First Report, 1931.

(4) Voelcker, Dr. *J. Bath and West Soc.* Vol. X, p. 183. 1862.

REPORT ON ADVISORY WORK, 1933-34.

The number of enquiries received in the Department during the year again shows a substantial increase over the previous period, comparison of the figures for the two years showing a nett gain of 691 in 1934.

It will be seen from the table of statistics which follows that a large and continuous rise in the number of enquiries has occurred during the past six seasons, the numbers for the first and last seasons of the six year period being 1,777 and 4,813 respectively.* The increase recorded during the past season is the result of steady increases in practically all of the thirteen subjects included in the table on which advice is given, ten showing increases and three only decreases.

370 of the increases were in connection with the work at Berkeley Square and 321 with that at the Long Ashton Station.

Large increases are recorded in Agriculture and Agricultural Chemistry (+ 162), Dairy Bacteriology (+ 179), Pomology (+ 82), Economic Mycology (+ 69), and Fruit Products (+ 142).

The increase in the work in Agriculture and Agricultural Chemistry is due to an all round development of activities, whilst the investigational work which the Adviser is carrying out on grassland and in connection with the Pig Survey, initiated by the Bath and West Society, results in much advisory work and is likely to lead to still greater expansion in the future. In Dairy Bacteriology the commencement of a County Accredited Milk Producers Register in Somerset has been largely responsible for the substantial increase in enquiries.

The increases in the requests for advice in Pomology are causing great pressure of work in that section since there is no adviser in the subject, and the enquiries are dealt with by members of the Pomological Research Staff, chiefly by the Plantations Officer, whose duties apart from advisory work are very onerous. Reference to the sectional report in that subject will indicate the urgent need for the appointment of a special officer to deal with Pomological enquiries or to relieve the Plantations Officer from some of his present duties.

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* The statistics for Poultry Pathology are not included in the Table (see later).

In Economic Mycology the increases are due to special activities of the Advisory and Research Mycologists in connection with vegetable diseases and fruit diseases such as apple scab.

The development in Advisory work in Fruit Products has been very rapid, two years ago the total number being only 25. It is the direct outcome of the research work of the Products Officer, the results of which have been eagerly sought after by manufacturers, both in this country and abroad.

Of the subjects which showed decreases in the numbers of enquiries, Cider Instruction (— 34), Domestic Preservation of Fruit and Vegetables (— 1), Willows (— 33), those under Cider Instruction are due to the withdrawal of Monmouthshire from the Scheme of Cider Instruction during the previous period, Worcester being the only county in the scheme during 1933–34, whilst those for the other two subjects may be regarded as normal fluctuations. In particular in the subject of Domestic Preservation of Fruit and Vegetables, as stated in previous reports, steps are being taken to decrease the advisory enquiries by training local advisers under schemes of the National Federation of Women's Institutes and other interested Educational Bodies. The number continues to be large in spite of these measures.

As in previous reports, it must be emphasised that all officers responsible for the various sections of advisory work are working at very high pressure and, in the case of subjects which are dealt with by the Long Ashton Staff, the large volume of work entailed in many enquiries tends to interfere seriously with the continuous progress of research work.

A point requiring special mention in the present report is the success achieved in the Poultry Pathology Section. This section was established by the University at the request of County Officers and poultry keepers in the Province, on a self-supporting basis, relying entirely on fees received for work done. It appears to be filling an urgent need in the scheme of poultry educational work. During the year a large increase in advisory work was recorded, 73,751 blood tests and 653 post-mortems being made as against 52,879 blood tests and 404 post-mortems in the corresponding period of the previous year.

Advisory work is now classified under fifteen heads, viz.: Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Pomology, Horticultural Chemistry, Economic Mycology, Economic Entomology, Insecticides and Fungicides (formerly Disease Control Materials and Methods), Fruit Products, Domestic Preservation of Fruit and Vegetables, and Willow Growing. Statistics relating to enquiries are available for all subjects excepting Agricultural Economics, where the method of working does not lend itself to the statistical tabulation of enquiries since the personnel of the section concentrates on special problems of groups of farmers, and economic surveys of farming methods and specialised rural industries, and do not consider to any extent the special cases of individuals other than as they arise in group and survey studies.

The nature of the enquiries in Poultry Pathology differ in character from those in other subjects, involving mainly routine laboratory tests, and since the numbers of these are very large, Poultry Pathology enquiries are most conveniently discussed apart from those of other subjects, and have therefore been excluded from the Table of Statistics and are referred to above.

Of the other thirteen sections for which statistics are available the following increases and decreases respectively are recorded :—Agriculture and Agricultural Chemistry (+ 162), Dairy Bacteriology (+ 179), Veterinary Science (+ 29), Cider (+ 30), Cider Instruction (— 34), Pomology (+ 82), Horticultural Chemistry (+ 8), Economic Entomology (+ 25), Economic Mycology (+ 69), Insecticides and Fungicides (+ 24), Fruit Products (+ 142), Domestic Preservation of Fruit and Vegetables (— 1), and Willow Growing (— 33).

The numbers of enquiries submitted to the Department during the past six seasons are summarised in the following table :—

	Year ending September 30th.					
	1929	1930	1931	1932	1933	1934
Gloucester (including Bristol) ..	230	365	414	871	849	945
Hereford	118	137	159	169	310	337
Somerset	325	482	553	578	810	997
Wiltshire	235	219	265	343	481	476
Worcester	148	256	323	399	455	496
Other Areas	721	1025	919	960	1217	1562
	1777	2484	2633	3320	4122	4813*

* Statistics for Poultry Pathology are not included.

The figures under " Other Areas " include enquiries from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute. These counties do not rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Province for advisory purposes relating to Horticulture, whilst close touch is kept with the advisory personnel of both counties through the medium of the Horticultural Sub-Committee of the Provincial Advisory Council.

The data do not include numerous enquiries dealt with in personal interviews during survey work, local investigations, shows, etc.

The following features referred to in the sectional reports which follow call for special mention :—

Agriculture and Agricultural Chemistry.

In addition to dealing with an increased number of requests for advice in these two subjects, further sections of the Grassland Investigational Programme, which has been in progress for several years, have been completed and detailed information is now available on many of the problems affecting grassland in the West Country. Unfortunately, no further progress has been made in the elucidation of the Teart problem in Somerset. A comprehensive set of experiments was initiated in collaboration with the Veterinary Adviser and the owner of some grassland reputed to be very teart, but once again, owing to the prolonged drought, no teartness developed, and the animals, which were purchased for the experiment and allowed to graze over the affected area, showed none of the typical symptoms of the disease, and they were sold in the autumn to the butcher in good condition.

Coincident with the increase in activities in the recently-established Poultry Pathological section, a large number of requests for advice were received on the nutrition of poultry, and this aspect of advisory and investigational work now occupies a prominent place in the general activities of the Department.

Investigations with regard to the chalk soils of Wiltshire and Hampshire and the relative value of sugar beet factory waste lime are being carried out in collaboration with the Advisory Chemists at other centres. In the Spring of the present year the Experiments Committee of the Bath and West Society commenced a study of the systems of pig husbandry in the seven South-Western counties, and the Adviser and the County Agricultural Organiser for Wiltshire agreed to act as joint honorary investigators.

A series of broadcast talks was given in the West Regional Programme, and these talks are being continued. The value of the microphone as a medium for the dissemination of agricultural knowledge will be readily appreciated.

Dairy Bacteriology.

The progress of the Dairy Bacteriological section noted in previous reports continues, and during the year under review the number of samples examined shows an increase of 70% over that of the preceding period. This increase has been largely due to the commencement of a County Accredited Milk Producers Register in Somerset, following the successful Clean Milk Competition conducted in that county during the winter months, and to the extension of the existing County Accredited Rolls.

The enquiries for advice show a corresponding increase. Apart from the usual advisory problems relative to clean milk production, the diagnosis of mastitis by examination of milk samples has been a feature of the year's work; also several other interesting local problems have been investigated by the Dairy Bacteriologist.

Private, trade and local Health Authorities samples have been well maintained, and excellent co-operation exists between all parties concerned.

During the year the Department has undertaken the testing of milk samples, under the Ministry's Butter Fat Scheme, for the Bristol and North Somerset Milk Recording Society.

Agricultural Economics.

In addition to the usual advisory work based upon farm accountancy data, three special reports were issued during the year.

The survey of willow growing in Somerset referred to in the report for the previous year was followed by a survey of willow growing in the valleys of the rivers Severn, Avon and Stour.

The second report summarised the results of the investigation into problems of management for milk production, and a further report on this subject is in course of preparation.

The third report to be issued was on the results of the first year's enquiry into the economics of poultry farming, and this will shortly be followed by a similar report on the second year's results.

Veterinary Science.

An increase in the requests for advice and in the number of specimens submitted is recorded. Heavy losses among sheep from parasitic gastritis and enteritis have occurred, particularly in

Somerset, and several outbreaks of the same nature were encountered in yearling cattle. Treatment with a mixture of copper sulphate and nicotine sulphate (40%) gave, on the whole, good results in dealing with this condition. Among dairy cattle Johne's disease and sterility in abortion infected herds continue to be sources of serious financial loss to the farmer.

Poultry Pathology.

The second year's working of the Poultry Pathological laboratory has fully justified its establishment, and the work of the Poultry Pathologist may be regarded as an essential feature of the general advisory scheme in the Bristol Province.

Over 73,000 blood samples were examined and 650 pathological specimens were received for post-mortem report. In addition, the Poultry Pathologist has assisted the Veterinary Adviser to the extent of paying some 75 advisory visits.

It will be remembered that the Poultry Pathological section was established at the request of the counties of the Province on a self-supporting basis, and it is largely as a result of the co-operation of the County Staffs and the poultry farmers in the Province that it has made such excellent progress.

Economic Entomology.

The year again produced a further increase in enquiries over the large numbers previously recorded. Not only were those connected with fruit pests, horticulture, etc., fully maintained, but a considerable increase in the number received in connection with the diseases and pests of hops was recorded, and also a number concerning the pests of farm crops.

Much interest has been aroused among fruit growers by the introduction of "mixed" washes, developed by the pathologists at Long Ashton, which have been used successfully for various purposes during the past season. Examples of such washes are lime sulphur-nicotine-lead arsenate and lime sulphur-white oil emulsion, the former being designed to combat apple scab, capsid bugs, apply sawfly, aphis and codlin moth, and the latter apple scab and red spider.

In addition to fruit investigations, special lines of work include the continuance of extensive trials in connection with the bionomics and control of the pea strain of the eelworm *Heterodera schachtii* and the control of Flea Beetles by means of special dressings.

Both investigations have yielded hopeful results, but further experiments are required.

Good results were obtained in the control of *Phyllopertha horticola*, the so-called Garden Chafer, on pasture land. Work in connection with the insect pests of Hops is being continued and extended.

Economic Mycology.

In Economic Mycology there was an increase of 69 advisory letters over those of 1933, and despite the dry season of 1934 the time of the Advisory Officer was very fully occupied during the summer with advisory work.

Mr. B. O. Mulligan, N.D.H., Assistant for Vegetable Diseases, relinquished his post and was succeeded by Mr. P. W. Brian, B.A.

The special investigations on vegetable diseases have been continued, and as will be seen from the detailed report of the Adviser these now cover a wide range of crops. This work was made the subject of a lecture at a Revision Course in Horticulture at Reading University on September 11th.

The more important investigations in progress during the period under review, other than those concerning vegetable diseases, concerned apple fruit spots, in relation to the fungus flora of the twigs, strawberry root rots, virus and related diseases of fruits, various root diseases of ornamental plants and obscure hop diseases.

Willow Growing.

The natural control of the fungus and insects pests of the willow crops, which resulted from the dry weather conditions of 1934, has been outstanding. These abnormally dry conditions have prevented progress in the field experiments on pests and fungi and have also vitiated results in manurial investigations.

The improvement in the fruit basket making industry mentioned in the 1933 Report has led to enquiries for varieties of willows such as the new hybrids raised at this Station, which are more suitable for this purpose than those now grown.

The extensive planting of cricket bat willows continues to absorb the annual production of bat willow sets. In spite of the dissemination of advice given personally, by letter, and by pamphlet, it may be safely assumed that within the next ten years large numbers of willow trees will be valueless for bat making due to the planting of wrong varieties, lack of the correct appreciation of the soil requirements of the tree, improper cultivation and to the planting of badly grown sets.

The personnel of the Department, and in particular the special Advisory Officers, wish to place on record their keen appreciation of the valuable co-operation and help which they have received from the County Agricultural Staffs, and from farmers and fruit-growers of the Province in carrying out much of the advisory work described in this report.

The salient features of the work of each section during the year are summarized below :—

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

Once again a substantial increase in the number of requests for advice has to be reported, and it is due largely to the wholehearted co-operation of the County Agricultural Organisers and members of the Assistant Staff in the Agricultural Chemistry Department of the University—particularly Mr. H. T. Watkins, M.Sc., and Mr. W. R. Muir—that it has been possible to cope with the ever-increasing volume of work.

The grant for two years made by the Agricultural Research Council in connection with grassland investigations came to an end on April 30th, 1934. As a result of this grant, together with previous grants from the Ministry, the Bath and West Society and private donors, it has been possible to complete certain sections of the grassland investigation programme which has been in progress for several years. The Department is now in possession of critical data—the value of which cannot be over-stressed so far as advisory and future investigational work are concerned—upon the following aspects of grassland :—

(*a*) The effect of different systems of manuring and management on the nutritive value of grass and hay.

(*b*) The influence of local conditions of soil and climate in the West Country on the nutritive value of herbage.

(*c*) The monthly nutritive value of the herbage of water meadows, cow-pastures and Wiltshire Down land under conditions of both good and bad management.

(*d*) The “ mineral ” content of West Country pastures.

(*e*) The iodine content of certain pastures.

(*f*) The effect of folded poultry on the chemical composition of relatively poor pastures.

(*g*) The losses that occur in the making of grass silage in the stack, with and without the use of molasses, A.I.V. solution and ordinary water.

(*h*) A comparison of the yields and nutritive value of fodder obtained by the practices of :—
    (1) Grazing.
    (2) Hay making.
    (3) Silage making.

A valuable contribution on the geology of the Bromham area of Wiltshire has been received from Mr. H. G. Dines, of the Geological Survey, in connection with the soil and utilisation survey of that area which has been carried out in collaboration with the Agricultural Organiser for Wiltshire.

As in former years, specimens of weeds, herbage plants and rocks have been received for the purpose of identification and report as to commercial value or poisonous properties, and the co-operation of the Departments of Botany and Geology in the University is readily acknowledged.

The provision of advice on poultry nutrition has now taken a place among the advisory activities of the Department, and the volume of work involved has steadily increased since the Poultry Pathological Laboratory was set up in October, 1932.

During the year ended September 30th, 1934, 595 requests for advice were received, which is an increase of 162 over the previous year. Five hundred samples were examined in the laboratory, and 242 advisory visits were paid.

A few notes on some of the samples are appended :—

Soils.

As in previous years, most of the soils were concerned with the problem of soil deficiencies either in lime or plant food.

Fertilisers and Limestones.

The nature of the manures, limestones and lime products received indicated that farmers are still attempting to make better use of by-products from various processes of manufacture. Thus, wool waste, hoof and horn, dried poultry manure and sewage sludges are typical examples of the samples received.

Feeding Stuffs.

An increased number of feeding stuffs were received for microscopic analysis as being suspected of bringing about digestive and other disorders in farm animals.

Waters.

Consequent upon the prolonged drought experienced this summer and the effort of farmers to obtain new sources of drinking water, the number of water samples has increased considerably. Some waters, however, were received as suspected of bringing about illness and deaths in animals.

Viscera.

The viscera received were sent in with a view to tracing either metallic or alkaloidal poisoning—the latter mainly as the result of food impurities, such as weed seeds.

Investigations Completed During the Year.

(1) Grassland.

(*a*) *The Seasonal variation in the nutritive value of some typical pastures in the Bristol Province.*

The results of this investigation which has been in progress for five seasons are summarised in the table below. The data have been obtained from the examination of herbage samples collected at three-weekly and monthly intervals. By good management is meant the adequate and efficient stocking of the grassland in question, together with such economical manuring as may be required.

(*b*) *Grass Silage.*

The losses in dry matter content and nutritive value that occur in making grass silage in the stack have been investigated during the past two seasons. Certain of the experiments, particularly those with A.I.V. solution, have been carried out in collaboration with the research staff of Imperial Chemical Industries, Ltd., and the Organiser for Wiltshire. A report on the results is in course of preparation.

(2) Arable Land.

(*a*) Chilian Potash Nitrate as a fertiliser for sugar beet.

(*b*) The effect of mole draining on the mechanical and chemical composition of the soil.

Type.	Management.	Food Ingredient.	Monthly Variation as Percentage of Dry Matter.											
			Jan.	*Feb.*	*Mar.*	*Apl.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Water Meadow	Good.	Dig. Crude Protein ..	14	15	23	19	16	16	15	17	22	19	17	15
		Starch Equivalent ..	63	69	66	70	66	63	63	65	65	62	58	57
	Bad.	Dig. Crude Protein ..	7	7	9	9	8	8	7	7	9	9	8	7
		Starch Equivalent ..	49	51	59	61	60	57	56	58	60	56	54	50
2nd Grade Cow Pasture.	Good.	Dig. Crude Protein ..	12	13	19	17	14	13	14	15	15	16	13	12
		Starch Equivalent ..	63	63	68	70	69	66	65	68	68	67	64	63
	Bad.	Dig. Crude Protein ..	6	8	14	15	9	9	9	11	10	9	7	6
		Starch Equivalent ..	55	55	65	68	63	60	62	60	57	57	56	55
Down Pasture.	Good.	Dig. Crude Protein ..	7	7	8	12	12	12	12	11	12	10	8	7
		Starch Equivalent ..	51	51	51	70	68	66	66	67	69	66	57	54
	Bad.	Dig. Crude Protein ..	5	5	5	7	8	6	6	8	8	7	6	5
		Starch Equivalent ..	43	43	42	63	61	55	55	58	59	54	44	44

Investigations in Progress.

(1) The Teart Lands of Somerset.

At the beginning of the grazing season, arrangements were made for the detailed study of the teart problems on a farm in Somerset. Stock were purchased, fields fenced and details agreed upon with the Advisory Veterinary Officer for post-mortem examination of affected animals. Once again these efforts to investigate the problem were thwarted by the prolonged drought, and no " teartness " developed in the area.

(2) The Chalk Soils of Wiltshire and Hampshire.

A study of these soils, particularly with reference to mechanised farming, is being made in collaboration with the Advisory Chemist at Reading, and the Organisers of the two counties concerned.

(3) The Bath and West Society's Pig Investigation.

This investigation is being carried out by Mr. W. T. Price, the Agricultural Organiser for Wiltshire, and Mr. A. W. Ling, who have been appointed joint honorary investigators.

(4) Sugar Beet Factory Waste Lime Experiments.

Arrangements have been made with Mr. Morley Davies, of the Harper Adams Province, for the establishment of a joint centre for the two Provinces at Pattingham, near Wolverhampton. The trial will take the form of a 7 × 7 Latin Square, and the value of the waste lime from the Allscott and Kidderminster factories for the sugar beet crop will be compared with that of a standard ground limestone.

(5) Experiments with Dried Poultry Manure.

These experiments, which form part of a series established in certain Provinces at the request of the Ministry of Agriculture, have been designed to test the manurial value of dried poultry manure for market garden and vegetable crops.

Other investigations, outlined in the previous report, are being continued.

General.

Broadcast Talks.

In the autumn of 1933, an experimental series of talks and discussions under the headings of " For Western Farmers in Particular " and " The Market Special," were arranged in collaboration with the West Regional Director of the B.B.C. " For Western Farmers in Particular " was intended to be a regional supplement to " For Farmers Only," as broadcast in the National Programme, and " The Market Special " was a broadcast edition of the " Market Ordinary "—the local name given to the market lunch in certain towns. " For Western Farmers " took the form either of a straight talk or a discussion with some appropriate person, such as an Agricultural Organiser, or a prominent farmer, on a current topic. " The Market Special " resolved itself into a meal-time chat between a farmer, a consumer and an " expert," in the main centred around the Marketing Schemes of the Ministry. All the talks had an educational background, and twelve were broadcasted in the period under review. Apparently the experiment met with approval, as the talks are now being given fortnightly from the West Regional Transmitter and a similar arrangement has been adopted by the B.B.C. for certain other regions.

DAIRY BACTERIOLOGY.

The requests for advice both from the productive and distributive trades continue to increase. 425 enquiries have been received and 6,349 samples examined in the laboratory. In addition, 34 advisory visits were made in order to deal with special technical problems.

During the period under review, Clean Milk Competitions were held in Somerset and Worcester, and one has recently been commenced by the Gloucestershire Milk Recording Society. Schemes for County Registers of Accredited Milk Producers have received special consideration by the educational staffs concerned, and at the present time there are County Rolls in Wiltshire with a membership of 74, Worcestershire with 19 and Somerset with 30 members.

Private Testing Scheme.

Every endeavour has been made to cater for farmers who, either by ineligibility or situation, are unable to join the accredited registers in operation and who are anxious to have samples examined at monthly intervals. The scheme functions in the same manner as an accredited register except that no surprise samples are taken and the results are not circularised. At present some forty farmers are regularly submitting samples.

Local Health Milk Samples.

Owing to the county of Gloucester having been divided into three areas for the purposes of bacteriological analysis of milk samples taken by sanitary inspectors, the number of samples submitted from that county to the department is lower than that for the previous period. The loss, however, has been more than balanced by the activity of two sanitary inspectors in North Wilts, who commenced submitting samples at the beginning of this year. In the latter instances excellent co-operation is maintained between the sanitary authority and the County Agricultural Orgainser, and, as the samples are examined solely for educational purposes, the unsatisfactory cases are immediately investigated by the county staff.

Competitions.

The usual quota of advisory work arose during the Clean Milk Competitions, but no specific problems were discovered, the faults chiefly concerning the persistence of *B. Coli* contamination. The first sample submitted by each competitor was examined microscopically for mastitis and all positive and doubtful cases reported.

Prior to the commencement of the Somerset Competition two rounds of advisory samples, one ordinary and one surprise, were submitted from each competitor. The information thereby revealed, coupled with a knowledge of the methods employed on the farm, allowed the dairy staff to give much useful advice, and in some cases a third advisory check sample was submitted. Thus the competitor was allowed time to put his house in order before the competition actually commenced. The value of this work is clearly shown in the following table, where the bacteriological quality of the advisory and competition samples is compared :—

	Certified Standard. %	*Grade "A" Standard.* %	*Below Grade "A."* %
Advisory Samples ..	51.1	18.9	30.0
Competition Samples ..	79.7	10.9	9.4

Mastitis.

Apart from the enquiries relative to the presence of *B. Coli* in graded milk, which have been frequent, and of complaints of poor keeping quality by the trade, the number of enquiries concerning mastitis have been a noteworthy feature of the year's work. Of the total number of samples, including bulk and individual cow samples, examined under this heading, 23% were found to be positive.

Ropy Milk.

Six outbreaks of ropiness have been investigated and in four cases the fault was soon controlled. In two instances, however, the usual remedial measures were unsuccessful. In view of the sporadic nature of these two cases, it is felt that there was some unknown factor of prime importance determining the development of the ropy condition.

Special Advisory Work and Investigation.

"Carrot" Taint in Milk.

The development of a flavour highly reminiscent of carrots has been noticed in milk samples from one farm. Early attempts to isolate an organism failed, but later, by incubating the milk agar plates for 4—5 days at 37° C, very minute colonies developed and the organism isolated therefrom was found to produce the "carrot" flavour.

Further work on the biological characters of the organism is being conducted as time permits.

Torula Yeast in Cheese Milk.

A complaint from two farms of severe gassiness in cheese-curd was brought to the notice of the Dairy Bacteriologist in June last. While *Coliform* contamination was not entirely absent from the bulk milk samples, the nature of the gassiness in the curd strongly suggested that yeasts were the major cause of the trouble.

Samples from suspected cows in the herd, carefully drawn direct into sterile bottles from the last portion of the milk produced after the udders had been thoroughly cleansed, showed an abundance of yeasts, probably *Torula cremoris*. The findings of this investigation would lead one to suggest that the yeasts originated from the interior of the udder, but as a teat-siphon has not been available for taking samples, final confirmation is withheld meantime.

High Acidity in Milk.

A case has occurred where a low grade sample of crushed oats was considered responsible for very high acidity in newly-drawn milk. On three separate occasions when 5 lbs. of the oats per head were fed to the cows, the newly-drawn bulk milk showed abnormally high acidity, so high indeed, that the milk clotted on boiling, and in one instance slight coagulation was noticed when the bulk milk passed over the cooler. A sample of the oats when examined showed evidence that the grains had, at some time, undergone considerable fermentation. Upon digesting the oats in water at 37° C for 24 hours a strong odour of acetic acid developed, and agar-plate cultures of the supernatent fluid produced an almost pure culture of *Bacterium aceti*. Control samples of sound oats when treated in a like manner produced no acetic acid fermentation, nor could *B. aceti* be isolated from plate cultures.

Methylene Blue Reductase Test.

Interest in this test has been renewed and the Dairy Bacteriologist is participating in the correlation work on this subject with some other advisory centres and the National Institute for Research in Dairying, Reading.

General.

In April last, this Department undertook the testing of milk samples under the Ministry's Butter Fat Testing Scheme for the Bristol and North Somerset Milk Recording Society. Several members have already taken up the scheme, and others have signified their intention of doing so as from the commencement of the new milk-recording year.

AGRICULTURAL ECONOMICS.

(1) Enquiries and Advisory Work.

Advisory work in economics is now based entirely upon data arising from financial accounts and enterprise studies. During the year there has been no change in policy, but a consolidation and intensification of the work already in hand. The number of producers who keep some kind of record for the Economist has steadily increased during the year, chiefly as a result of farmers introducing their friends. The analysis made later under Section (2) shows the types of farms from which records are received.

(2) Investigational Work.

The following summary is given :—

(a) Financial Accounts.

During the year 135 financial accounts were dealt with. The classification is given below :—

Proportion of Permanent Grass.	*No. of Farms.*	*Type of Farm.*	*No.*
0 — 30%	4	Fruit and Market Gardening	3
		Milk	1
31 — 70%	58	Fruit and Market Gardening	3
		Milk	19
		Cattle and Crops	6
		Mixed	30
71 — 100%	73	Milk	31
		Cattle and Crops	6
		Mixed	36
	135		135

(b) Surveys.

In the Spring of 1934 a survey was made of the willow-growing industry in the valleys of the rivers Severn, Avon and Stour. The results of this enquiry were not published, but a report was made to the Ministry of Agriculture and to the County Organisers concerned. The total area inspected by the Advisory Economist amounted to 135½ acres. Generally speaking, the variety of willows grown and the system of cultivation differ considerably from those found in Somerset.

(c) Enterprise Studies.

(i) *An Enquiry into Management for Milk Production.* This has been continued during the year under review, and it is hoped that a second report will shortly be issued so that comparison can be made with the results of the previous year's investigation. Thirty farmers have co-operated in the scheme.

(ii) *Poultry Farming.* This investigation has just been completed for the second year, and a detailed report is in course of preparation, so that it will be possible to compare this year's position with that of the previous one. Thirty-two farmers have collaborated with the Economist.

(3) General.

Customary Meetings.

The customary meetings with groups of farmers in order to examine and discuss the results of farm management investigational work were held at various centres in the Province.

VETERINARY SCIENCE.

(1) Enquiries and Advisory Work.

Advisory work has been continued and, as anticipated, requests for advice and the number of specimens submitted have increased. The Poultry Pathological Department has taken over much of the work in connection with poultry disease problems, with a consequent decrease in avian specimens examined by the Adviser. Enquiries concerning sheep and pigs have increased considerably. 501 requests for advice were received, 621 pathological specimens were examined, and 128 advisory visits were paid during the year.

Some notes on the diseases of animals encountered in the Province are appended :—

Sheep.

Losses among sheep due to parasitic gastritis and enteritis have been extremely heavy, particularly in Somerset during last winter and spring. Last year's lambs showed symptoms of parasitism in the late autumn with fairly heavy losses, though on the whole treatment with copper sulphate was moderately successful. In the spring severe outbreaks, entailing a high mortality, occurred among in-lamb ewes, and many of the affected ewes that survived were unable to rear their lambs. Fairly good results were obtained by drenching with a mixture of nicotine sulphate and copper sulphate. The parasites responsible were found to be mainly *Trichostrongylus* species. Twenty-six outbreaks were investigated by the Adviser, the findings in these outbreaks being embodied in Bulletin No. 10.

The use of serum, administered to lambs soon after birth, is being widely adopted and has been extremely successful in the control of lamb dysentery. No fresh outbreaks in areas previously free have been reported.

Several outbreaks of navel ill were encountered where insufficient care as regards hygiene was taken in the lambing pens. On many farms in Somerset the infection appears in the form of multiple abscesses in the liver, the condition being termed " spotted liver " locally. Lambing the ewes in fresh premises or another field was successful in controlling further losses.

Cattle.

Several severe outbreaks of parasitic gastritis in yearling cattle have been met with, and such cases have given little response to treatment. Keeping the animals indoors on a nourishing diet has saved a number, but losses on one or two farms have been very high.

Requests for advice concerning contagious abortion have increased considerably. The numbers of cases reported where animals abort on two and even three consecutive occasions are remarkably high and appear to be on the increase. Sterility in abortion-infected herds continues to be a serious source of annoyance and financial loss to the dairy farmer.

Other diseases of cattle concerning which advice has been sought include mastitis, Johne's disease, etc.

Pigs.

Heavy losses in pigs soon after weaning were found in several instances to be caused by *B. Suipestifer*. Very careful disinfection of premises at regular intervals was successful in controlling the spread of the disease.

Among young pigs anaemia has caused quite heavy losses. In one outbreak the pigs which recovered remained stunted and developed a skin eruption which on rubbing became infected and purulent with consequent death of the animal. On the adoption of measures to control the anaemia the skin eruption no longer appeared.

In a few outbreaks of broncho-pneumonia, chronic cough and unthriftiness, *B. Suisepticus* has been isolated in pure culture from affected lungs.

Precautions against parasitis, *e.g.* round worms, appear to be a general routine on many farms. A plentiful supply of whey in place of drinking water is apparently an excellent vermifuge against the large Round Worm.

Poultry.

Many of the problems concerning diseases of poultry have been undertaken by the Poultry Pathologist. All the common poultry diseases have been encountered and several outbreaks of fowl typhoid have occurred in the northern part of the Province. Parasites, particularly *coccidia*, have caused serious losses during the year.

(2) Investigational.

Investigations have been continued on the " Teart " land problem and further trials with various drugs in the treatment of parasitic gastritis have been made.

POULTRY PATHOLOGY.

There has been a decided increase in the number of blood tests and post-mortems carried out during the period under review over the previous year, and the laboratory has rapidly established itself as an essential unit in the Agricultural Advisory Scheme in the Province.

During the period 73,751 samples of blood were submitted for testing for Pullorum disease, and 653 pathological specimens were examined.

In the assistance of the Advisory Veterinary Officer in investigating outbreaks of disease, 75 visits were made to farms in the Province. A survey of diseases encountered will be found in the Veterinary Adviser's report.

Egg Laying Trials.

The Poultry Pathologist acted in the capacity of Veterinary Surgeon on the Reception Committee receiving the birds at the Somerset and Wiltshire Laying Trials.

CIDER.

617 enquiries, including 60 under the Cider Instruction Scheme in the County of Worcestershire, received attention during the year. 292 of the requests came from areas outside of the Bristol Province and, as usual, among these were included a number from abroad, Ireland, Jersey, Australia, New Zealand, India, British Columbia, France, Denmark, Sweden and the United States being represented.

In connection with the enquiries, 86 analyses of cider and a considerable number of determinations of alcohol, volatile acids and sulphur dioxide were carried out.

A large proportion of enquiries were of a general character in connection with cider making processes and machinery, but there were several features of particular interest among the requests, of which the following require special mention : the utilization of market varieties for cider making ; the use of the centrifuge in cider making ; the suitability of various new alloys in cider making machinery and as fittings ; various chemical aspects of cider making.

The enquiries relating to the use of market varieties came mainly from the Eastern and South-Eastern Counties.

As the result of advice given in connection with the use of the centrifuge, this machine has been used with success during the season, in attempts to retain cider in a sweet condition.

New metals have been suggested for piping, pumps and bottling apparatus.

Among chemical problems were nitrogen estimations in relation to problems of fermentation rate, ash analyses, phosphoric acid content of ciders, tin and copper determinations in cases of suspected metallic contamination, hydrogen-ion concentration in relation to acidity and taste of cider.

During the year, Worcestershire was the only county under the Cider Instruction Scheme.

The Cider Instructor paid 95 visits to farmers in that county in connection with problems relating to cider making and cider orcharding.

In view of the fact that there is a decreasing demand for the rougher type of farmhouse cider, special attention has been paid to the production of high-class beverages on the farm, and this has necessitated instruction in the improved methods of handling fruit and the management of the fermentating juice.

Co-operative cider-making is progressing in one part of the county, where one centre is being utilized for the milling and pressing of the fruit. More attention to cider orcharding is being given both by farmer-cider makers and by farmers who sell their fruit, the fact being more generally realised that good cider varieties and efficient orchard management are essential for profitable results.

POMOLOGY.

620 enquiries were received, including 280 from areas outside the Province. Several requests emanated from abroad, Scotland, Wales, Ireland, U.S.A., and others being represented. The total

shows a further increase of 82 over the previous year. 73 visits were paid in dealing with the problems raised. The enquiries concerned many aspects of fruit production, the following being of special importance : spraying of farm orchards, spraying technique ; miscellaneous problems of soft fruit culture, especially strawberries ; pruning, rootstocks, varieties ; planting schemes for new orchards. Demonstrations of winter pruning of apples and of the use of the Station mobile spraying plant were given to two organised parties of fruit growers at Long Ashton at the request of the growers concerned.

In addition to the above, the staff of the pomological section have received at Long Ashton large numbers of visitors interested in general problems of pomology, and have demonstrated the work in progress at the Institute to numerous organised parties. This latter feature has imposed a great strain on the personnel of the section, since this work is mainly done outside of normal working hours.

The preparation of the pomological report of the survey of the Evesham and Pershore fruit areas is well advanced.

HORTICULTURAL CHEMISTRY.

130 enquiries, including 55 from sources outside the Province, were received. The large proportion of requests which came from outside the Province is the result of the interest of commercial fruit growers in various districts in the results which have been obtained at Long Ashton, relative to the nutrition of horticultural crops and in particular to fruit plots. Overseas enquiries came from Canada, Argentine and Russia.

The subjects of enquiry were generally similar to those of previous years, the majority relating to manurial problems of orchards and fruit plantations, the suitability of soils and sites for fruit growing, failures of fruit trees, market garden and glasshouse crops, and chlorosis of fruit trees and garden plants. The large number received concerning the suitability of soils and sites for fruit growing reflects the continued interest in fruit planting.

Fruit storage problems, especially bitter-pit and cork, were again fairly frequent subjects of enquiry, the season again being very hot and dry.

Investigations in Progress.

1. *Experiments on the Control of Lime-Induced Chlorosis in Apples, Pears and Plums—in Somerset and Worcester.* The

results obtained from injection of fruit trees with ferric citrate continue to be of promise, and the treatment appears of commercial value.

2. *Survey of Soils on the Lower Lias Formation.* Work was continued in the Martock fruit area and in the teart areas in Somerset. Mapping was considerably curtailed by the drought conditions which prevailed during 1934.

Survey work has also been commenced in the Long Ashton district, and a detailed soil map of the Institute Farm has been made.

The soil section of the report on the Evesham Pershore area has been completed, and soil maps on a 6in. to 1 mile scale prepared.

ECONOMIC ENTOMOLOGY.

The number of enquiries received was 829, which shows an increase of 24 over the previous year. Personal visits totalled 282. The main subjects of enquiry were :—The control of Apple Sawfly, Red Spider, Raspberry Moth, Plum Sawfly, Codling Moth, Leaf-Eating Weevils (*Phyllobius spp*), Strawberry Tarsonemid, Flea Beetles of root crops, White Fly of Brassicas and Chrysanthemum Eelworm ; especial interest was shown in the use of combined washes for fruit.

The main investigations in progress were as follows :—

Combined Summer Washes for Apple Trees.

Experiments were carried out with combined washes applied at the " green flower," " pink bud " and " petal fall " stages for the control of scab and the major insect pests. A combined lime sulphur-white oil emulsion wash was tested as an ovicide for capsid and red spider control, and as a protective fungicide against scab. Special attention was given to methods of improving the petal fall washes in order to prevent foliage damage. Various wetting compounds were tested out. The results have made it possible to recommend some of the washes with confidence.

Apple Sawfly.

Further experiments arising from previous investigations were carried out, mainly to check certain conclusions and to ascertain the ovicidal properties of nicotine. Rotenone was also tried with encouraging results. Further confirmatory experiments are necessary.

Apple Blossom Weevil.

Preliminary laboratory and field experiments were commenced on the use of derris and silicofluoride preparations as means of controlling this pest. The results indicated that the use of derris as a repellent has been over estimated.

Combined Control of Plum Sawfly and Red Spider.

Preliminary field investigations were carried out to ascertain if the spray programmes used against Apple Sawfly were applicable to Plum Sawfly. It was shown that the spray dates were difficult to determine.

Raspberry Moth *(Incurvaria rubiella).*

Preliminary field experiments were carried out to ascertain the possibilities of controlling the insect before it entered the buds in spring.

Capsid and Big Bud Control on Black Currants.

Previous experiments with mixed tar oil-petroleum washes were repeated, and the results confirmed those previously obtained regarding the efficiency of these as means of controlling Green Capsid. A mixed wash of lime sulphur and white oil emulsion was successfully applied after bud burst and adequately controlled capsid ; it is hoped that Big Bud will also be controlled by it.

Derris.

Laboratory toxicity trials were commenced with derris and its constituents as a basis for further studies.

Chrysanthemum Eelworm.

Investigations on this pest were completed and the results published. It was shown that hot water treatment of the stools provided the only means of control among the methods tested.

Flea Beetles.

Extensive field trials were continued with a special seed dressing. The results were most encouraging despite abnormally severe attacks of these beetles. Further confirmatory experiments will be carried out.

Eelworm *(Heterodera schachtii).*

Calcium cyanamide and formaldehyde were used as soil dressings to control this pest. Both gave encouraging results, especially the former.

Asparagus Miner *(Melanagromyza simplex).*

Further investigations, in collaboration with Dr. H. F. Barnes, of Rothamsted, completed the main facts of distribution and life history, and a conjoint account was published.

Hops.

A survey of the pests of hops was continued and sufficient data have now been obtained to enable control experiments to be carried out in the near future.

ECONOMIC MYCOLOGY.

396 enquiries were received, which number shows an increase of 69 over the previous period.

Following are the chief diseases on which detailed work was carried out during the period under review :—

Fruit.

Diebacks of Apple Trees.

Further work has been done on diebacks of apple trees in the Bristol Province and their relation to certain feebly parasitic fungi. A number of cases in Worcestershire have been kept under observation and the associated fungi have been isolated and tested for pathogenicity. No highly parasitic fungus has been isolated ; the feebly parasitic *Valsa ambiens* previously encountered has been found to be widespread.

Fruit Spots and Fruit Rots.

Several of the fungi causing prevalent fruit rots have been inoculated on to healthy and burned twigs, but most are able to persist and multiply only on dead twigs.

Such twigs form an important source of fruit infection.

Strawberry Root Rots.

An investigation on strawberry root rots as they occur in the Province was carried out. Fungi identical with those isolated by Berkeley in a parallel series of investigations were obtained from root rots in the Province. A small number of the fungi appear to be actively parasitic, such as *Cylindrocarpon radicicola.*

Miscellaneous Strawberry Diseases.

A note was published on a disease of strawberries prevalent in the Province which may be identical with the American " Crinkle." In the disease in question there is a marked " clearing of the veins," accompanied by mottling and transparent spots which dry out into reddish or purplish areas. Severely affected plants are much dwarfed and flattened.

Miscellaneous Virus Diseases of Small Fruits.

Stocks of seedlings have been raised in insect free conditions of certain small fruits, such as raspberries, black currants, red currants, and work on certain obscure virus diseases of these has been commenced.

Virus Diseases of Tree Fruits.

Symptoms suggestive of Atanasoff's " Plum Pox " have been found to be prevalent, and this and other possible virus diseases of tree fruits are being kept under observation.

Vegetables.

Further progress in the investigation of vegetable diseases has been reported on by Ogilvie and Mulligan in the last Annual Report of the Institute. This work has also been reported on in a series of articles in the Worcestershire Agricultural Bulletin, and in a lecture in the Reading University Revision Course.

This year there has been useful co-operation on the part of several leading seedsmen.

Mr. Mulligan who has been specially identified with the work on vegetable diseases, has now left to take up commercial work, and has been succeeded by Mr. P. W. Brian. Mr. Mulligan's work was followed closely by growers, with whom he was in intimate contact.

Asparagus.

Rust (*Puccinia Asparagi*). Despite one small outbreak in 1933, no asparagus rust has been found in the Province this year.

Violet Root Rot (*Rhizoctonia Crocorum*). Trials of various vegetables were laid down on areas in which asparagus had been affected. The following vegetables were attacked by the fungus: beets, mangolds, parsnips, carrots and potatoes. Dwarf beans and clover were not affected.

Beans (Dwarf).

Halo Blight (*B. Medicaginis* var. *phaseolicola*). Owing to the dry summer this disease was not prevalent.

Foot Rot (*F. Solani* var. *Martii*). As in the case of peas the *F. Solani* var. *Martii* group have been found to be the most pathogenic. Variety trials were laid down in the Evesham area and although no varieties were very markedly resistant several apparently resistant seedlings were marked and the seed of these was saved.

Beans (Runner).

Wilt. Further work was carried out on the *Fusaria* responsible for wilt.

Bacterial Disease. A new bacterial disease of runner beans is under investigation. This causes leaf spots with concentric markings and shot holes.

Brassicae.

Finger-and-toe. Trials of the new organic mercury disinfectant " Brassicol " have been carried out.

Celery.

Soft Rot. This disease, apparently caused by *Bacillus carotovorus*, is becoming of serious importance to growers around Bristol and elswhere. A study of the disease is in progress.

Leeks.

White Tip (*Phytophthora Porri*). Seedlings from apparently resistant plants have been worked up.

Lettuce.

Ring Spot (*Marssonina panattoniana*). Fungicidal treatments were again ineffective but the varieties Arctic and MacHatties Giant were again found to be somewhat resistant.

Winter Killing (associated with *Botrytis sp.*). The following appear to be somewhat resistant: Arctic (Arctic King), Imperial, Yates Winter White, Lees Immense and MacHattie's Giant.

Mosaic. Mosaic of lettuces is of great importance in the Province. In 1933 several plantings had over 90% infection. The disease appears to be readily transmitted in the seed and preliminary experiments indicate that it is probably transmitted from plant to plant by the aphis *Macrosiphum Sonchi*. This aphis occurs on Sonchus and groundsel and on lettuces late in the autumn and early in the spring.

Mint.

Rust (*Puccinia Menthae*). The aecidial stage of *Puccinia Menthae* causes much damage to forced mint in the Province. Further trials have again shown that a late spraying of 5% tar oil prior to lifting, is of value.

A collection of species and varieties of mint has been got together, and numerous seedlings have been raised ; some of these appear to be somewhat resistant to rust.

Onions.

White Rot (*Sclerotium cepivorum*). Tests have been made of various organic mercury disinfectants applied to the drill before sowing.

Peas.

Sickness (*Heterodera Schachtii*). This trouble has been investigated in co-operation with the Advisory Entomologist. Further trials have shown that applications of calcium cyanamide and of formalin (2%) enable plants to produce a normal yield in infested soil.

Foot Rots. Many *Fusaria* have been isolated from infected plants, but those of the *F. Solani* var. *Martii* group are the most pathogenic.

Potato.

Sickness (*Heterodera Schachtii*). Further striking results have been obtained from the use of 2% formalin. 1% formalin is not usually effective.

Tomato.

Spotted Wilt. This disease was not found to be carried over in the seed. Callas (*Richardia*) were found to be commonly affected in greenhouses where the trouble was prevalent on tomatoes.

Vegetable Marrow.

Mosaic. This trouble has disappeared from fields where previously it had been found every year and from the hedgerows of which affected White Bryony plants had been removed.

Ornamentals.

Fusarium Wilt of Asters.

The Fusaria responsible for aster wilt in the South West have been identified by Wollenweber as *F. conglutinans* vars. *callistephi* and *majus*. Certain American varieties were found to be highly resistant in 1933, and again in 1934.

Lily Diseases.

The Adviser, as a member of the Royal Horticultural Society Lily Research Sub-Committee, is frequently approached on the subject of lily diseases.

Mosaic. The aphis *Myzus Convolvuli* has been found to be associated with the spread of lily mosaic out of doors, seedlings grown out of doors becoming heavily infected. Thirty-five species of hardy lilies have been found to be affected in the open in England.

Root Rots. The fungus *Cylindrocarpon radicicola* has been found to be associated with root rots in several species of hardy lilies in England, and may be responsible for failures as it is in Holland.

Bulb rot. Moore and the Adviser have examined species of *Rhizopus* from rots of *L. auratum*. It is thought that the species *R. necans*, described by Massee, may not be distinct from *R. nigricans*.

Delphinium Root and Stem Rot.

A root and stem rot associated with *Thielavia basicola*, and troublesome to local growers, is being investigated.

Willows.

Rust.

Further field experiments on the control of the Triandra rust (*Melampsora Amygdalinae*) were laid down, but were inconclusive owing to the dry season. An article on willow diseases was prepared as an appendix to an economic survey of the willow industry.

Hops.

Virus Diseases.

Little progress was made with this project since the hop seedlings raised under controlled conditions died off during the winter months.

INSECTICIDES AND FUNGICIDES.

The officer responsible for this section took over his duties in December, 1933. From that time the number of enquiries received was 66, of which 53 were from sources outside of the Province.

During the period, 55 samples of spray materials were analysed, 19 coming from growers and advisory officers. or from manufacturers, and 29 being of materials employed in spray trials and research work. 15 of the samples consisted of textile wetters used or suggested for use as spreaders, 21 of proprietary oil preparations and 13 of derris products. 16 interviews were given to representatives of 9 commercial firms interested in the manufacture of spray materials.

The majority of the enquiries from growers and advisory officers concerned the use of oil sprays and of certain new materials introduced as spray spreaders.

The officer has served on a Sub-Committee, appointed by the Conference of Advisory Entomologists in December, 1933, for the purpose of considering possible additions to the insecticides listed in " Specifications and Methods of Analysis for certain Insecticides and Fungicides." Ministry of Agriculture Bulletin, No. 82. A memo on draft specifications and methods of analysis for tar and petroleum oil preparations was prepared for the Sub-Committee.

FRUIT PRODUCTS.

280 applications for advice were received which number shows an increase of approximately 150% over that for the preceding year. The number included 196 from areas outside of the Province, including 52 from London, and others from Ireland, Scotland, Canada, India, New Zealand, South Africa, U.S.A., Argentine, Germany and Hungary. 53 visitors were received at Long Ashton to discuss various commercial aspects of the subject. The main subjects of enquiry were: brandies, wines, syrups, juices, concentrates, apple pomace and enzymes. 50 analyses of materials and products were carried out.

The large and rapid increase in enquiries in this section is due solely to the fact that manufacturers and growers have quickly appreciated the possibilities of the commercial application of the results which have been obtained at Long Ashton during the course of the past three seasons, over which period the subject of Products has been actively investigated and substantial progress made in the preparation of attractive products from various fruits on a laboratory scale.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

229 advisory enquiries were received during the year, as compared with 230 during the previous period. As is usual in this section, where the instructress is in touch with centres throughout the country, the majority of enquiries (191) came from sources outside the Province. The requests included 6 from Scotland and one each from South Africa, Federated Malay States and Australia.

The main subjects of enquiry were as follows: the making of jams and marmalades, including problems of setting, crystallization, use of commercial pectins, and mould growths; bottling and canning of vegetables; preservation of mushrooms and quinces; pickling of capers and nasturtium seeds; storage and pickling of walnuts; crystallization of cherries, chestnuts, etc.; use of sulphur dioxide as a preservative for fruit; use of various articles of equipment and of machines for preserving, etc.

Lectures, Demonstrations and Classes.

These were held as usual under various authorities and organisations at the following centres:—

Lectures and Demonstrations: Derby, Trowbridge, London, Oxford, Kettering, Leicester.

Classes: Derby, Redhill, Guildford, Chester, Studley Horticultural College, Leicester.

Courses of Instruction.

Three courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, from July 24th to August 31st, and on this occasion, through the kind co-operation of the Ministry of Agriculture and the East Anglian Institute of Agriculture, the instruction was given by Miss Jameson, instructress for the latter authority. The courses were again attended to full capacity.

In co-operation with the National Federation of Women's Institutes, a second course in Methods of Teaching Fruit Preservation for the training of demonstrators was given at Cirencester from September 5th to 7th. Of the 12 students enrolled, 10 took the course, of whom 7 gained certificates, 3 first class and 4 second class awards. Miss Jameson and Miss Gunnell (Devon C.C.) assisted in this work.

General.

Judging of produce was undertaken at the British Dairy Farmers' Association Show in London, and at Women's Institutes Produce Exhibitions at Gloucester, Newbury, Worcester, Southampton, Norwich, Exeter, Chester, Leicester and Bath.

The closest co-operation has been maintained with the National Federation of Women's Institutes, and the instructress has served on the Agricultural Sub-Committee of this body, and also on the Executive Committee of the Gloucestershire Federation of Women's Institutes.

WILLOW GROWING.

234 enquiries were received which number is 33 less than in 1933. 114 of the requests were from areas outside the Bristol Province.

The main subjects of enquiry referred to : pest control ; cultural treatments of old and new beds ; suitability of land and varieties ; cricket bat willow culture.

A feature of the season has been the unusually slight damage caused by insect pests and fungus diseases, the dry conditions appearing to exercise a powerful natural check on these.

Cultural enquiries generally related to the treatment of new and old beds. In the former cases manurial treatment could be advised, but in the latter it was generally necessary to recommend grubbing and reverting to grass or substituting bat willows for the basket varieties.

In view of the recent interest in the planting of cricket bat willows, much advice has been given in connection with all phases of culture, sites, sets, methods of planting and treatment of the growing trees.

The officer continues to draw attention to the fact that much unsuitable planting is still being carried out, and this can only result in great disappointment and financial loss in years to come.

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